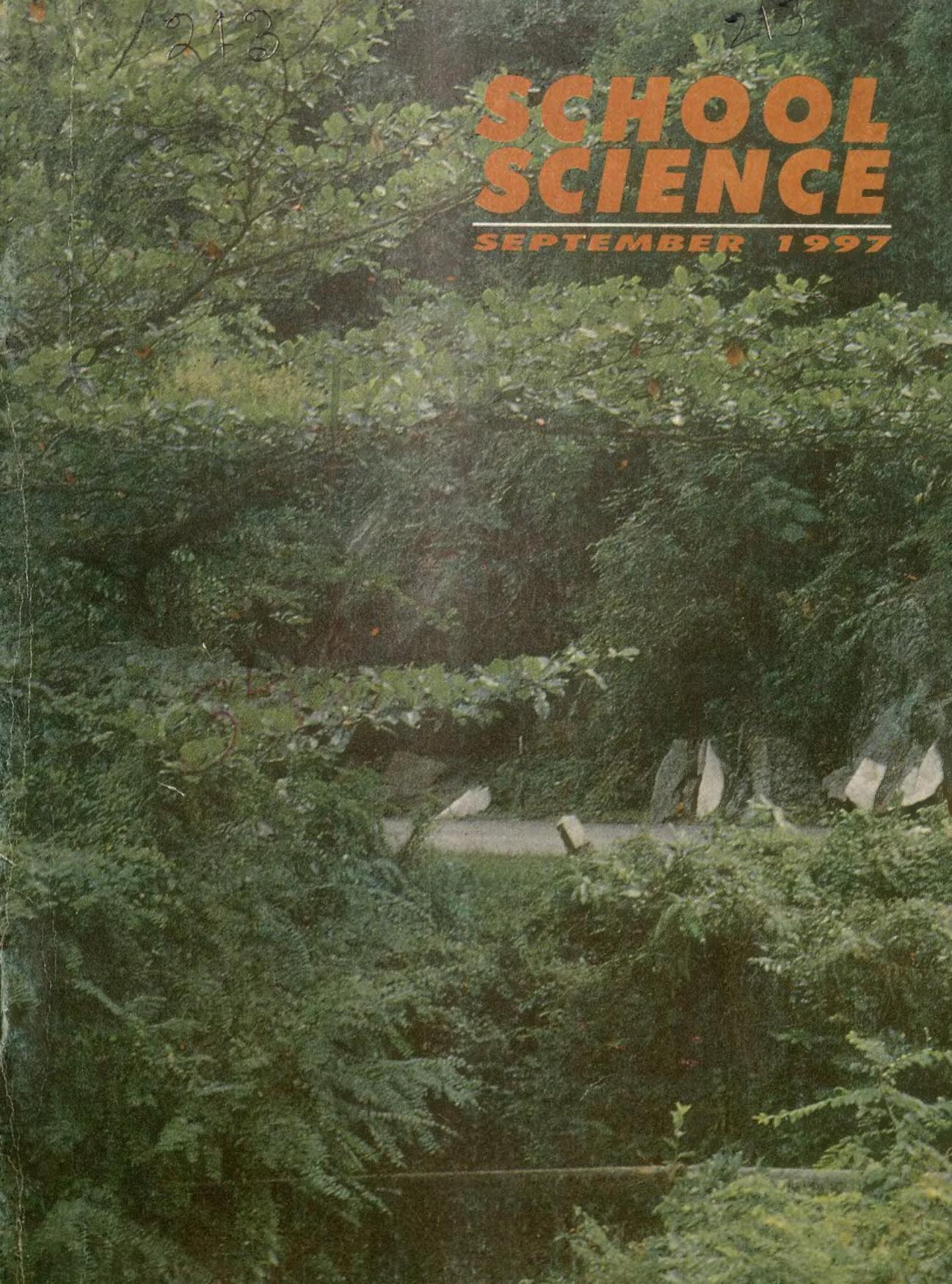


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# SCHOOL SCIENCE

SEPTEMBER 1997



SCHOOL SCIENCE is a journal published quarterly by the National Council of Educational Research and Training, New Delhi. It aims at bringing within easy reach of teachers and students the recent developments in science and science methodology, and serves as a useful forum for the exchange of readers' views and experiences in science education and science projects.

Articles suitable to the objectives mentioned above are invited for publication. An article sent for publication should normally not exceed ten typed pages, and it should be exclusive to this journal. Illustrations should be drawn with pen and indelible ink. Photographs (black and white), at least of postcard size, should be on glossy paper and should be properly packed to avoid damage in transit.

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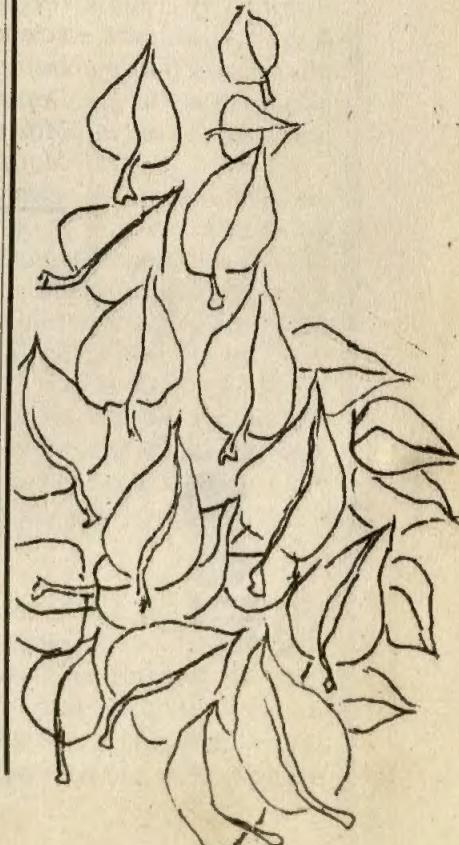
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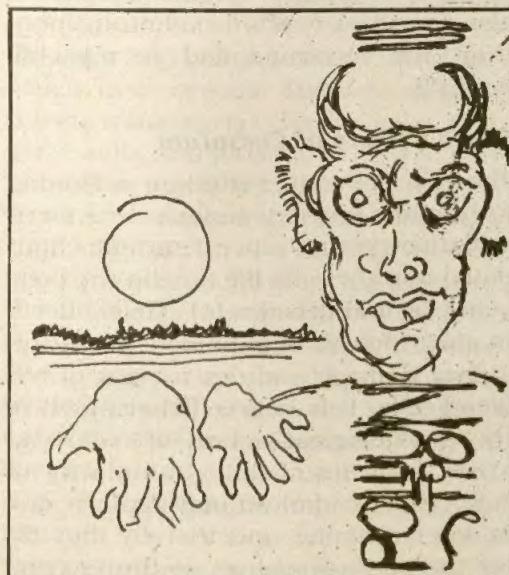
# Environmental Pollution Due to Cadmium, Mercury, Lead, Arsenic

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New Delhi 110 016



**R**

ecovery of metals has been an ancient trade and the toxic effects of the metals, particularly

lead and mercury were not unknown to our ancestors. But a phenomenal increase in industrialisation, urbanisation, increase in vehicular traffic and the use of fertilizers and pesticides in agriculture have resulted in increased contamination of our environment by metals. The impact of metal pollution on human health and its global significance have thus become a major issue of public concern in the last few decades. One of the glaring instances of poisoning, due to metal-mercury in this case, has been the "Mianmata Disaster" in Japan, where thousands of people in Mianmata, a fishing village in Japan, were affected in the '50s, due to mercury poisoning from a chemical plant which discharged its mercury containing residue into the Mianmata Bay. A similar tragic instance that faces India today, is the poisoning of water due to arsenic (a metalloid) in certain districts of West Bengal.

To give an idea of this problem, we shall discuss here, in some detail, the issue of environmental pollution due to four of the most polluting elements—cadmium, lead mercury and arsenic. In the previous issue of the Journal we have given an overview of the pollution due to these four elements, and in the forthcoming issue, we shall discuss briefly, the efforts being taken to remove these from the environment.

## Cadmium

Cadmium is regarded as one of the highly toxic elements in the environment. The natural sources of cadmium are volcanic activity, ocean spray and forest fire. However, emission of cadmium to the atmosphere

from anthropogenic sources exceeds those from natural sources. Non ferrous metal mines, smelters and refineries, coal combustion, refuse incineration, iron and steel industry and phosphate fertilisers are the main sources of cadmium to the environment due to human activities. Cigarette smoking contributes significantly to cadmium intake and tobacco containing cadmium is present as a finely dispersed aerosol\* in cigarette smoke. Chemically, cadmium being very similar to zinc, these two metals frequently undergo geochemical processes together. Also since cadmium in native state occurs in association with zinc minerals, growing plants which require zinc, take up cadmium along with zinc. Food is, therefore, the main route by which cadmium enters the human body. Sea food and organ meat generally have high levels of cadmium, but majority of cadmium in the diet usually comes from potatoes, wheat, rice and other grains. Since cadmium uptake by plants increases with decrease in pH, therefore, acidic soils help increase cadmium level in food.

Although  $Cd^{2+}$  is rather soluble in water, human beings usually receive only a small proportion of cadmium from drinking water (or directly from air). Exception occurs, however, for individuals who live near mines and smelters, particularly the ones that pro-

cess zinc. Tobacco smoking and occupational exposure (specially mining and electroplating) increase the risk of cadmium intake by human beings (1). Smokers are also exposed to cadmium that is absorbed by tobacco leaves from irrigation water (2).

In India, the maximum detected level of cadmium in air has been reported in West Bengal; in water in Kerala and Andhra Pradesh; and in food in Punjab and Haryana. It has been observed that more than 50% of the soil samples from Punjab and Haryana are sandy with low in organic matter, low in pH and deficient in zinc, conditions favourable to promote cadmium uptake by plants. Sea water from Bhavnagar in Gujarat, used for preparation of salt is also found to contain cadmium more than the recommended permissible limit (3).

#### **Toxic Effects of Cadmium**

The effect of acute cadmium poisoning in humans are very serious. It is a cumulative poison, since it is not eliminated quickly — its life time in the body being several decades (4). Toxic effects mainly include high blood pressure, kidney damage and destruction of red blood cells. It is believed that much of the physiological action of cadmium arises from its chemical similarity to zinc. Thus, cadmium may replace zinc in some enzymes and thereby may alter the stereostructure of the enzyme and impair its catalytic activity (5).

Historically, all serious episodes of cadmium contamination have resulted from pollution from the nonferrous mining and smelting industries. The most alarming of these being the one

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\* aerosols are colloidal systems in which liquid, or sometimes solid particles, with a diameter measuring about  $10^{-2}$  mm to  $10^{-6}$  mm are distributed in a gas phase (such as air). Such two-phase distributions can be artificially produced by aerosol products.

that occurred in the Jintsu river valley in Japan where people contracted a bone disease called "itai itai" (in Japanese). In this disease, some of the  $\text{Ca}^{2+}$  in the bone apparently gets replaced by  $\text{Cd}^{2+}$ , since both  $\text{Ca}^{2+}$  and  $\text{Cd}^{2+}$  share same charge and virtually same size\*. The bones gradually become porous, leading to fracture and collapse (6).

### Mercury

Mercury has long been part of our environment, it existed long before any industrial development, and over the millennia living beings have developed tolerance to the small doses of natural mercury. Mercury is present in earth's crust, but the major sources of natural mercury are the natural "degassing" (evaporation) of the earth's crust through volcanic gases and the evaporation from oceans. Mercury exists in the environment as the metal, as inorganic salts and as organic methyl mercury. Mercury is found as a trace component in many minerals, fossil fuels coal and lignite — a matter of some concern — because of increased use of these fuels as energy sources. Mercury is leached from soils (some of this mercury being accumulated by human activities as well), into water systems by natural processes. Depending on the species, plants also accumulate mercury through three routes: from the soil through their roots, from the atmosphere through the stomata and by retention of particulate mercury (7). Though India does not have an indigenous production of mercury, but be-

cause of the toxicity and polluting nature of mercury, India shares with the rest of the world, great concern for mercury as a heavy metal pollutant (8).

In recent years, it has been established that flooding of vegetated areas can release mercury into water. Dimethyl mercury,  $\text{Hg}(\text{CH}_3)_2$  results from contact of soil bound  $\text{Hg}^{2+}$  with anaerobic bacteria produced by the decomposition of immersed organic matter. In this way, previously insoluble inorganic mercury gets converted to a volatile dimethyl mercury. The less volatile  $\text{CH}_3\text{HgX}$  ( $\text{X}=\text{Cl}, \text{OH}$ ), often collectively known as "methyl mercury" are formed in a similar way, only more readily than dimethyl mercury. An acidic medium promotes the conversion of dimethyl mercury to methyl mercury. This is a more potent toxin than dimethyl mercury or elemental mercury, because it is soluble in fatty tissues in animals and therefore bioaccumulates\* and biomagnifies\* there. Most of the mercury present in the human body is in the form of methyl mercury and most of it originates from fish in our food supply. The half life period of methyl mercury in human beings is about seventy days. Consequently methyl mercury can accumulate in the body, even if, on a daily basis, a person consumes doses which individually would not be harmful. Many of the well published environmental problems involving mercury have arisen in connection with the fact that in the methylated form, it is a cumulative poison (9).

\* The toxin can be taken up by living organisms so that progressively through predators, it magnifies to levels greater than the levels found in the environment.

\* Ionic radius of calcium is 100 pm and that of  $\text{Cd}^{2+}$  is 95 pm

Plants and soils have also been found to discharge gaseous elemental mercury at rates significant enough to affect the amount of this pollutant in air. Plant physiologists have shown that plants take up mercury and release it through transpiration, in a manner similar to the way methane moves from soil through rice plants (10). The phenomenon has been observed with aquatic plants growing in mercury contaminated sediments, but it was never suspected in terrestrial plants growing in basically clear soils. It has been observed that even soils that have not been directly affected by an industrial spill, and agricultural soils are also strong emitters of mercury vapours. The notion that mercury is re-emitted to the air from the earth's surface is not new, since the volatility of mercury is a well established fact. However, these findings suggest that natural processes may have a stronger effect on the amount of mercury that gets into the atmosphere than previously thought and not all the mercury that gets into the atmosphere is necessarily coming from human activities. It is found that a form of water soluble divalent gaseous mercury compound (a gas also identified in stack gases and from industrial sources) make upto 1 to 5% of the mercury in ambient air.

The discovery of natural emission of mercury from soils and plants suggests that managing mercury emission to the environment may differ from other pollutants, since unlike the other pollutants, reduction of mercury emission due to anthropogenic reasons may not be the solution for removing this polluting agent from the environment.

Measured gas phase emission of mercury has been estimated to 100 nanogram/square metre/hour over a forest canopy and upto 75 nanogram/square metre/hour over soils. These amounts are low in comparison with those from industrial sources, but the difference is that, for every coal fired power plant, there may be thousands of square kilometres of forested areas (11).

The anthropogenic sources of atmospheric mercury have increased substantially in the 20th century and now match with the input from volcanoes — formerly the predominant source of airborne mercury. However, the principal use of mercury has undergone great changes in recent decades. At the turn of the century, the main uses of the metal were in the recovery of gold and silver — uses which have essentially disappeared. Applications in agriculture, pharmaceuticals and general laboratory practices have also declined in the last twenty years, whereas applications in electrical apparatus, chloroalkali plants and dental filling have increased. Taken individually, each of these may not contribute much to the toxic metal in the environment, but their total effect can be substantial. The most significant anthropogenic activity of all, that gives rise to emission of mercury to the environment is, burning of fossil fuels and industrial processes (12).

In India since most of the thermal power plants use pulverised coal, this may cause a major threat to the environment as far as mercury pollution is concerned. Not only is the mercury content of coal in India higher than that of coal used elsewhere in the world, but

the coal used being of lower grade, the consumption of coal per unit of power production in India is also high. It is thus predicted that mercury emission for each unit of power generated in India is also high. Because vapour pressure of mercury is very high, and due to the high combustion temperature, even with the most effectively controlled fly ash control systems, a major fraction of mercury is still emitted to the atmosphere, which condenses on dust particles. To study this and related phenomena, the National Environmental Engineering Research Institute (NEERI at Nagpur), had recently conducted an ecological survey of the distribution of mercury in air, soil and vegetation, around the Kobra thermal power station in central India. One of the observations of this survey was that a slightly higher level of mercury is observed in winter on soil, may be due to increased fuel combustion, and poor dispersion of pollutants in the winter evenings. In summer, mercury levels are slightly lower, because mercury evaporates more into the atmosphere due to higher temperatures. The survey observed that the level of mercury in air is minimum in post monsoon periods may be due to a washout of pollutants from the system. The survey also found that as one goes down below the surface, the subsoil mercury levels decrease in comparison to the top soil mercury (13).

### Toxicity of Mercury

Elemental mercury is fairly inert and not toxic and if swallowed, it is excreted without serious damage. However, since mercury has a high vapour pressure, it

is volatile and if inhaled enters the brain through the blood stream. This can lead to severe damage of the central nervous system. Hence, mercury should be handled only in well ventilated areas and if spilt, should be cleaned up as quickly as possible.  $Hg^{2+}$  (mercurous ion) forms an insoluble chloride with  $Cl^-$  and since our stomach contains fairly high concentration of  $Cl^-$ ,  $Hg^{2+}$  is not toxic.  $Hg^{2+}$  (mercuric ion), however, is fairly toxic because of its high affinity to sulphur atoms. It easily attaches itself to sulphur containing amino acids of proteins.  $Hg^{2+}$  also forms bonds with haemoglobin and serum albumin, both of which contain sulphydryl groups.  $Hg^{2+}$  does not, however, travel across biological membranes and so it has no access to biological cells (14). The most toxic species are the organomercuric compounds particularly methyl mercury  $CH_3Hg^+$  because it is soluble in fatty tissues in animals, and therefore, and it bioaccumulates and biomagnifies there. Once ingested,  $CH_3HgX$  interacts with the sulphur containing amino acids. In some of these forms it is soluble in biological tissues and can cross both the blood brain barrier and the human placental barrier, presenting a two-fold hazard (15). The covalent Hg-C bond in these compounds is not easily disrupted and the alkyl mercury is retained in cells for prolonged periods of time. The attachment of mercury to cell membranes may inhibit active transport of sugar across the membrane while allowing the passage of potassium across the membrane. In case of brain cells, this results in energy deficiency in the cell and disorders in the transmission of nerve im-

pulses. Thus, babies born of mothers exposed to methyl mercury poisoning suffer an irreversible damage to the central nervous system (16). In addition to the direct toxicity of alkylmercury compounds, their slow decomposition to inorganic Hg (II) ion may lead to secondary toxic effects as well.

### **Lead**

Lead is considered to be one of the severe environmental contaminants to arise in human civilization. Lead is a natural constituent of the earth's crust and occurs naturally in plants. In the environment lead exists almost entirely in the inorganic form. Lead bearing limestone and galena (Pbs) contribute lead to natural water in some locations. The zawar deposit in Rajasthan is the only source of lead in India (17).

Lead is a trace element and is present less than 0.1% by weight in rocks and soils. But soil is a sink for anthropogenic lead and this has helped in lead accumulation in the environment as a result of widespread use of lead by humans. Mining, smelting activities, sewage sludge usage in agriculture, and above all gases discharged by automobile exhausts are some of the well recognised sources of anthropogenic lead in the environment. Lead is "particle active" which results in effective scavenging of lead by particles in many lead emissions and environmental cyclic processes. This accounts for the effective transport of lead in particulate phases and its accumulation in many environmental materials e.g. terrestrial urban soils, estuaries and near shore sediments (18). However, there is a general agreement that only a small

proportion of lead in soil is available for uptake by plants, although there is little evidence that lead is readily lost from soil profiles by leaching. Lead has a long life time in the atmosphere compared with most pollutants. Lead and its compounds accumulated in soils and sediments are found to be of low solubility. They also have relative freedom from microbial degradation and remain accessible to the food chain and to human metabolism for a long time in future. The life time of lead in soil is so long that it can be regarded as permanent component in soils. Fortunately, alongwith low solubility and mobility, the bioavailability of lead is also low (19).

Food is the major source of lead intake for most people. Most lead enters articles of food during storage and processing e.g. canning, brewing etc. Acidic media and high temperature facilitates leaching of lead from glazed pottery sold in North India. (Though not a food item, but "surma" used predominantly in India also has a high lead content).

A major source of lead in the environment is petrol, as tetraethyl lead is added to petrol to prevent spontaneous premature combustion of the fuel mixture and knocking. The effectiveness of tetraethyl lead as an antiknocking agent relies on its ability to get easily oxidised to lead oxide. The lead oxide so produced enters the human body through inhalation and skin contact. Tetraethyl lead is also readily absorbed through the skin, the amount so absorbed increases with area of skin involved. However, the possibility of human contact with leaded petrol other than through occupational exposure is

slight. The link between lead and petrol, and lead in humans is well established. Children living near busy streets have been measured to have lead levels in their blood around 300 microgram/litre, while those living in rural areas with low traffic density have lead of around 150 microgram/litre, or even less. Studies have also shown links between amounts of lead present in breast milk and the density of traffic at the place where the mothers live (20). Lead from automobile exhausts and from industries accumulate in the form of dust; while a significant proportion of fuel lost by evaporation from the fuel tank and carburettor of vehicles add lead to the atmosphere as well. In addition, there is considerable loss of unburnt fuel from two-stroke engines of mopeds, motorcycles and scooters.

Lead is utilised in lead acid batteries and in yellow lead chromate used in road markings. Air bound lead oxide from many of the above sources eventually settles in soil, water, fruits or leafy vegetables and thereby enters the food chain. Microorganisms do bioaccumulate lead, but in contrast to mercury, lead does not undergo biomagnification in the food chain. Also, in contrast to mercury, lead does not generally become an environmental problem, until it is in the ionic form.

On an average, roads in Indian cities have been found to contain 2 gram of lead/kilogram of dust, with levels being alarmingly high in Calcutta, Delhi and Mumbai (Table 1.). According to estimates prepared by the National Environmental Engineering Research Institute (NEERI, Nagpur) the amount of lead in air by 2000 A.D. is expected to

be 103, 91 and 50 metric tonnes in Delhi, Mumbai and Calcutta respectively. (21). An analysis of lead content in water bodies and in food items have shown that, West Bengal leads in lead content in water, while food samples tested from West Bengal, Orissa and Himachal Pradesh have tested to contain traces of lead (22). To help reduce air pollution due to lead, the Government of India has decided that cars that are being produced/marketed to the four metropolitan cities of Calcutta, Mumbai, Delhi and Chennai, will henceforth not be allowed to have engines that use ordinary leaded petrol. The new cars for these cities are being fitted with special catalytic convertors which also converts other pollutants emanating from vehicular exhaust pipes, viz carbon monoxide, hydrocarbons and oxides of nitrogen to (non polluting) carbon dioxide, water and nitrogen (23). Since 1st April 1995, unleaded petrol (meant for the new cars) is being sold in these four cities and also in some other selected cities of India.

TABLE I  
**Level of lead in Calcutta, Delhi and Mumbai**

City	ppm	
Calcutta	1.0 16	WHO standard
Delhi	0.2 14	is 0.5 ppm
Mumbai	0.2 18	

Source : Chemical Industry News, April (1995) 530.

Lead has been a constituent of soldering material and some pipe formulations, so that household water may

have some contact with lead. Although lead is partially removed from most conventional water treatment process and hence concentration of lead in treated water is low, but because of lead used in plumbing, water that has remained in household plumbing for sometime, may accumulate perceptible levels of lead (alongwith zinc, cadmium, copper). Thus tap water should be allowed to run for a while before being used. However, due to a general decrease in the use of lead in plumbing, except in isolated cases, lead probably is no longer a major problem in drinking water.

### **Toxicity of Lead**

Most ingested lead in humans is initially present in the blood, but this amount eventually reaches a plateau and the excess amount then enters the soft tissues including vital organs, particularly the brain. Eventually the lead becomes deposited in bones, where it replaces calcium, because  $Pb^{2+}$  and  $Ca^{2+}$  are similar in size\*. Lead adsorption by the body increases in persons who have calcium deficiency and is higher in children than in adults. Lead remains in human bodies for several years. The dissolving of bones as occurs in old age or illness, results in remobilising of bone-stored lead, back into the blood stream where it can produce toxic effects.

Biochemically, lead interferes with the creation of haemoglobin by interfering with the enzymes involved in the process. At high levels, anaemia can

occur due to lack of this oxygen carrying component in the blood. High lead level also produces kidney impairment and causes permanent brain damage. The human group most at risk (from high levels of  $Pb^{2+}$ ) are children under seven years and fetuses, since lead readily crosses the placenta and is passed from mother to the unborn child.

On an atom to atom basis, though lead is not as dangerous as mercury, however, the general population is exposed to lead from a greater variety of sources, and generally at levels higher than those associated with mercury. Overall, more people are adversely affected by lead, though on the average, to a lesser extent, than those fewer individuals exposed to mercury (24).

### **Arsenic**

Arsenic occurs naturally as a sulphide associated with sulphides of silver, lead, copper, nickel, antimony, chromium and iron. Five per cent of the arsenic present in the atmosphere is in particulate form and originates due to the low temperature volatilisation of arsenic from soils by micro organisms. Volcanoes are the next most important natural source of arsenic. Although arsenic and its compounds are well known for their toxic properties, but fortunately the species that are most commonly found in soils are not the most toxic. However, arsenic is considered as one of the worst water pollutants. The uptake of arsenic by many terrestrial plants is not very high, even on soils which have a relatively high arsenic concentration. Therefore, plants do not usually contain dangerous levels of ar-

\* ionic radius of lead is 119 pm and that of calcium 100 pm

senic and only small background levels of arsenic is found in certain food items. Soils have been generally less badly affected by arsenic build up than aquatic sediments, and this lack of long term building up of arsenic in soils has been explained as due to the formation of volatile arsenic compounds by micro-organisms and by leaching (25).

Drinking water, especially ground water is a major source of arsenic for most people, as has been found in West Bengal. Malda, Murshidabad, Burdhaman, Nadia, Hughli, 24 Parganas have been considered as the most affected region of the world, as far as arsenic contamination is concerned; the districts of Howrah and Medinipur may also be affected. In these six districts, covering an area of 34,000 square kilometres with a population of 30 million, arsenic in ground water has been found to exceed the WHO limit of 0.005 milligram/litre. The conventional wisdom is that the source of arsenic is geological, experts however differ with this view as well (26). According to one school of thought, maximum withdrawal of ground water is causing arsenic contamination. According to this theory, poisoning started thirty years ago, when wells were sunk in rocks in the flood plains of the river Ganga, to irrigate new strains of rice during the dry season. They were unaware of the fact that the underground strata contained arsenic. Historically, the villages used surface water. But the new tube wells, which tap water from 150 metres or more below ground, provided abundant water to irrigate high yielding varieties of rice, that have revolutionised rice crops each year. Unfortunately, this

economic gain has come at a tragic human cost. Studies related to these affected villages have found seams of iron pyrites containing arsenic, which may be contaminating the wells. Poisoning probably onsets as soon as pumping starts, growing worse as over pumping lowers the water table in the rocks. As the water level falls, the arsenic bearing sulphide rocks dry out. Oxygen penetrates the rocks, oxidising the sulphide mineral. This in turn sets free the arsenic to be dissolved in the ground water. Wells which go below about 200 metres are usually arsenic free, at least until the water table falls further and oxygen reaches lower depths (27). Scientists of the Tropical School of Medicine, Calcutta, were the first to identify this widespread poisoning. Studies which are continuing, however, show that there may be other reasons as well. A study by the scientists of the Jadavpur University in Calcutta, on 20,000 tubewells of 560 villages of these 6 districts has shown that more than half of these tubewells showed water samples which contain 0.05 milligram/litre of arsenic, and in certain cases, the concentration is about 20 to 30 times more than what is regarded safe (28).

As far as anthropogenic source of arsenic is concerned, smelting of copper is the largest single input, representing about 40% of the anthropogenic total. Coal combustion is the next most significant source, which accounts for about 20% of the total anthropogenic arsenic. Much of the arsenic introduced into the atmosphere in this way ultimately reaches natural water. Arsenic produced as a by-product of copper, sil-

ver, lead refining greatly exceeds the commercial demand of arsenic and this accumulates as waste material (29). Due to similarity in properties, arsenic compounds coexist with those of phosphorous in nature, thus contaminating phosphate deposits and commercial phosphates (30).

### **Toxicity of Arsenic**

The toxicity of arsenic depends on its chemical and physical form, the route by which it enters the body, the dose and the duration of exposures (31). In fact, arsenic in minute quantities may even be an essential nutrient for living beings. Also arsenic by itself is rarely directly lethal, except when deliberately administered or ingested in amounts greater than 100 milligrams. However, arsenic poisoning is cumulative, with tiny amounts of arsenic building up in the bodies of the victims for many years, until physical symptoms emerge. Also, chronic poisoning leading eventually to deaths may also be frequent (32). The toxic activity of arsenic depends on its molecular form with mechanism of toxicity differing with the valence state of arsenic. Most organic arsenic compounds are substantially less toxic than the inorganic form — As (III) being more toxic than As (V). This is because, As

(III) can be retained in the body for longer time, because of its ability to be bound to sulphhydryl (-SH) groups of enzymes, thereby inhibiting enzyme action (33). As (III) compounds in high concentration form complexes with enzymes, they also coagulate proteins, possibly by attacking the sulphur bonds. The toxic mechanism of As (V) is less well understood than that of As (III). By virtue of its chemical similarity to phosphorous, arsenic interferes with some biochemical processes involving phosphorous (34).

In the initial stages, arsenic poisoning leads to chronic conjunctivitis, bronchitis and gastro enteritis. It eventually results in acute liver damage and gangrene. Arsenic is also known to be carcinogenic to humans, leading to lung cancer, skin and liver cancer. There is evidence that smoking and simultaneous exposure to environmental arsenic act synergistically\* in causing lung cancer. Its lethal effect when consumed in an acute dose is due to gastrointestinal damages resulting in severe vomiting and diarrhoea (35).

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\* i.e. their effects taken together is greater than what the sum of their individual effects would be, if each acted independently.

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35. Same as in 2 above.

# The Intriguing Story of the Jet Plane

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**T**he great explorer, Ferdinand Magellan, took nearly a hundred days to sail across the vast Pacific Ocean. Today, it is routinely criss crossed by modern passenger jet aircraft in a matter of hours. The jet engine (aircraft gas tur-

bine) has given an enormous impetus to the movement of people across countries and continents. Millions of passengers are moved every year by jet planes and families separated by half a world do not feel cut off from each other since they know that they are within a few hours of travel. The jet engine is one of the powerful forces that are inexorably drawing the global community together.

But strangely, such a revolutionary invention had to suffer an enormous amount of delay and obstruction in its development before it took off (literally). The two men who were most responsible for its initial development belonged to opposing nations locked in a bitter war, were unaware of each other's work, but proceeded on remarkably similar lines and met very similar kinds of obstructions. They were Frank Whittle (later Sir Frank) of Britain and Hans von Ohain of Germany. Their story proves that even in this age of Science and Technology, psychological resistance to change and innovation is no weaker than in the centuries past.

The concept of the jet engine was, paradoxically, quite well known and understood long before it reached fruition. Steam turbines have been used for electric power generation and marine propulsion for nearly a century now. Hence it was logical to anticipate the gas turbine as the next step. However, the materials to withstand the high temperatures and stresses encountered in the gas turbine were not available until the 1930's and aerodynamics of the gas flow through the blades was not well understood. But even when these technical obstacles were sufficiently over-

come, bureaucratic resistance to the idea proved to be an even greater hurdle in both Britain and Germany.

Frank Whittle was born in 1907 in Coventry, U.K. the son of a small machine shop owner. Even as a child he had an obsessive interest in aeroplanes and never thought of any career outside aviation. Poor physical build and health were his handicaps, but by persistent effort he got into the Royal Air Force (RAF) at the age of sixteen. At 19, he was selected to attend the RAF College at Cranwell. There he mastered the basics of the science of aviation and also became an expert pilot. In his final year in 1928, he wrote a thesis on "Future Developments in Aircraft Design" outlining the principle of what we now call the Turboprop engine, in which a propeller is driven by a gas turbine. Thereafter, the idea never left his mind.

Basically, the jet engine consists of a compressor, a combustion chamber and a turbine (see figure given below). The compressor, (A), spinning at a very high speed, draws in air, compresses it and feeds it to the combustion chamber (B) where the fuel is injected and burnt. The hot gas flowing out from the combustion chamber is expanded

through a turbine, (C) producing power. The turbine is mechanically coupled to the compressor and drives it. The gas leaving the turbine flows with a high velocity through a nozzle (D) into the atmosphere. The reaction to this gas flow propels the aircraft in the forward direction. As it has no reciprocating parts the gas turbine is very smooth in operation. Since it spins at very high speeds it produces a tremendous thrust for a light engine weight. With its introduction aircraft speeds almost doubled over night.

But with all its advantages, the jet engine had to face tremendous obstacles in its development. The basic cause was the conservatism of the human mind, which gets multiplied several fold in the case of Government bureaucrats! The British Air Ministry rejected Whittle's idea as "unworkable". His patent on the engine lapsed in 1935 for want of a paltry sum of money. But the persevering Whittle and a few intimate friends who shared his enthusiasm founded a private company named Power Jets to develop the idea. In 1937, the first prototype engine was tested. The racket that it made frightened even its creator but also elated him by its successful operation.

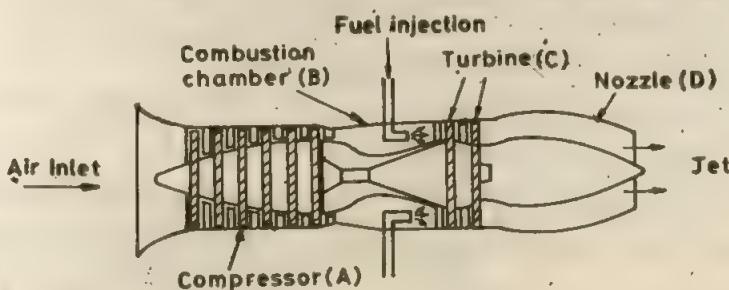


Fig. Schematic layout of a jet engine

The outbreak of the Second World War in September 1939 lent urgency to Whittle's efforts. He worked himself into a state of near nervous and physical collapse. In May 1941, Gloster Meteor, the plane fitted with Whittle's engine, was successfully test flown.

Meanwhile, strangely, an almost parallel development was taking place in Germany, with both sides being completely unaware of what the other was doing. Hans von Ohain was a brilliant young post graduate student of physics at the renowned University of Goettingen. In 1934, he too became interested in the possibility of the aircraft gas turbine. The model he constructed however failed. But he had a sympathetic professor who strongly recommended him to Ernst Heinkel, the famed aircraft manufacturer. Heinkel employed von Ohain in 1936 and allowed him to work on his idea — but in total secrecy. The secrecy was necessary partly to protect it from competitors, but even more importantly from government officials, who Heinkel feared would kill the project in its infancy. Later events were to prove that his apprehension was fully justified.

In the initial stages however, von Ohain was luckier than Whittle. Though he started some years later than Whittle, the support of Heinkel made all the difference. By early 1939, Ohain could demonstrate his engine successfully. Hitler was shown the engine, but was not impressed. Even the first flight of a jet plane, built around this engine, in August 1939, (a full 21 months earlier than Whittle's model !) failed to enthuse the Fuehrer or most of his airforce officials. The easy Ger-

man victory over France in May-June 1940 also robbed the work of any urgency. However, a few far sighted officials in the German Air Ministry realised its importance and awarded a contract for its development to the famous firm Messerschmitt. This firm too found it no easy task to proceed. They had to do it circumspectly against the opposition of the high officers of the Luftwaffe.

Finally, Messerschmitt got the first jet fighter, the Me262, flight tested in July 1942 and by the end of 1943, the plane was ready for mass production. Now Hitler became interested, but wanted it to be converted into a bomber, to retaliate against allied bombing of German cities ! It was a decision of monumental stupidity and set the programme back by nearly a year. Finally he relented and allowed the jet fighter to be produced, which saw action only in early 1945, too late to affect the outcome of the war.

Meanwhile in England, Whittle was finding it even more difficult to get his plane accepted, though the combined British and American industrial capacity was far higher than Germany's and these countries were not subjected to heavy bombing. But apathy and bureaucratic hindrance were even greater obstacles !

The American firm, General Electric, started taking an interest in Whittle's work in July 1941 and successfully flight tested its model of the jet plane late in 1942. Towards the end of the war the plane went into production but the fighting ended before it could be employed. It was only in the Korean War of 1950-1953 that jet fighters truly

came into their own.

But once the value of the jet engine was generally grasped progress was spectacular. Supersonic jet fighters for military applications were quickly developed. The first commercial jets, passenger planes, were introduced in 1958 and despite some initial setbacks elbowed out the piston engined planes within a few years. A supersonic passenger liner, the Concorde, was also developed. Today, huge jet planes carrying nearly 400 passengers or 100 tons of cargo are common place.

The jet engine has also been used to power small and moderate sized ships and in electric power generation.

Fame and rewards poured on Frank Whittle, though belatedly, after the War. He was knighted in 1948 and received a cash award of £100,000, tax free. Honorary doctorates were showered on him by Universities. But he had paid a heavy price for success in physical and mental health. He sought quiet appointments after the war and finally emigrated to the USA in 1976. There he taught at the US Naval Academy in Annapolis.

Hans von Ohain, belonging to a defeated nation, was not equally lucky with regard to recognition. He too emigrated to the USA to work for the US Airforce and teach at the University of Dayton. Whittle and Ohain met for the first time in New York in 1965 and became friends.

It is fascinating to speculate what would have happened if the development of the jet engine had been better

supported in the initial stages in Britain and/or Germany. In Britain, a jet fighter could easily have been built before the outbreak of the war. Its large-scale employment would have denied the Luftwaffe air superiority during the invasion of France in May 1940. Would the invasion then have succeeded? Even if it had, in the subsequent Battle of Britain, the German defeat would have come about earlier and more easily.

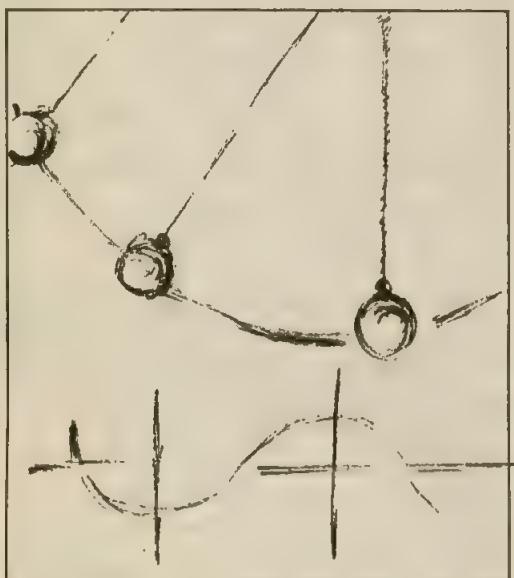
On the other hand, if the German authorities had a better vision than the British, they could have produced operational jet fighters by the beginning of the war. They could have easily won the Battle of Britain, inspite of the British possession of radar. Would they then have invaded Britain and would the invasion have succeeded? Even later, German possession of jet fighters would have undoubtedly stopped the allied bombing of Germany during 1942-1945 in its tracks. Would the allied invasion of Normandy in June 1944 have succeeded if air superiority had not been assured?

In an alternative scenario if both Germany and Britain had been more alert, they both might have had jet fighters right from the beginning of the War. Would that have meant cancellation of any advantage to either side, leading to approximately the same course for the war? None can answer these questions with certainty! All that is certain is that the Jet Age, brought about by the work of these pioneers, will take us closer to the day of the United States of the World.

# **Analysis and Interpretation Skills in Physics of Twelfth Grade Students**

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**T**he purpose of this study is to assess the analysis and interpretation skills in physics of twelfth grade students in India. Though a number of studies have been made in the

UK (APU, 1978; Kelly, 1982; Lock, 1986; Lock, 1989; Lock, 1990a; Lock, 1990b; Lock, 1992), Israel (Tamir, 1988), Japan (Kojima, 1974; Matsubara, 1986), USA (NAEP, 1975; NAEP, 1978), Canada (Hobbs et al., 1979), Australia (Parker, 1984) and Singapore (Toh, 1993) to assess the science practical skills of students, little is found in literature about the Indian students. The present work is an attempt in this direction. For this two paper and pencil tasks centered on graphs and set in physics context were administered to 225 students (162 boys and 63 girls) of grade 12 drawn from seven schools affiliated to the Central Board of Secondary Education (CBSE), New Delhi. The two tasks were designed to assess the analysis and interpretation skills as defined in the framework of Tamir's taxonomy (Tamir et al., 1992) of practical tasks. Within this broad category of, the present study tests the skills of graphing data, determining relationship, interpretation, prediction and formulating a generalization. Though the task designed for this study are simple and context familiar to students, the average score obtained in this test is only 38.5%. Further, difference between achievement of boys and girls in this test is found to be statistically significant only in prediction skills. Underachievement in science of girls compared to boys have been reported in a number of major studies done in this field in the USA (NAEP, 1978), Canada (Hobbs et al., 1979), UK (DES, 1980; Kelly, 1982) and Australia (Parker, 1984) as well as the First and Second IEA International Science Studies (Comber and Keeves, 1973; Postlethwaite and Wiley, 1992).

It is also found that there is some difference in achievement among schools.

The results obtained in this study clearly reveal the inadequacy of the curriculum prescribed at present in developing analysis and interpretation skills in physics. This raises serious concerns for curriculum developers, planners and Boards of Secondary Education in India. Implications of study are also discussed.

### **Method**

The data used in this study was collected through a test comprising two paper and pencil tasks. While designing the tasks, the presently used curriculum in physics was kept in mind and the tasks focused on the concepts of physics already taught to students. Text of the tasks is given in the appendix. The first task requires to plot a graph using the given data and then answering questions based on this. In the second task, two graphs are given and on the basis of these, a student is required to answer questions designed to test various process skills.

### **Sample**

The sample consisted of 225 students (162 boys and 63 girls) of grade twelve drawn from seven schools — six in Delhi and one

in Bangalore. The mean age of the sample is 17 years 3 months. All the schools are affiliated to the same Board — Central Board of Secondary Education, New Delhi and follow the same curriculum. Out of seven schools, 3 are Government schools, 3 are Central schools and one a public school. Composition of the sample in a school and type of schools are given in Table 1. For various reasons, name of the schools are not being given — rather schools have been given code as G1, G2, G3; C1, C2, C3 and P (G for Govt. schools, C for Central schools and P for the Public school).

### **Test Administration**

For this a student test booklet was designed similar to that used in IEA Second International Science Study (Kay et al., 1992) and was provided to each student just before the test. The test was administered in a batch of 20 to 25 students and each batch was briefed before the test. For each task, the time allowed was 25 minutes. A scoring grid was developed by the author and validated by the teachers. In order to minimize the inter-rater variability, all the booklets were marked by the author.

TABLE 1  
Composition of the Sample

School	Mixed Sex or Single Sex	Number of Students			Average Age of Students
		Boys	Girls	Total	
C1	MS	16	09	25	17Y 2M
C2	MS	37	13	50	17Y 5M
C3	MS	15	08	23	17Y 1M
P	MS	26	08	34	17Y 2M
G1	SS	46	0	46	17Y 4M
G2	SS	22	0	22	17Y 3M
G3	SS	0	25	25	17Y 2M
Total		162	63	225	Average age of sample 17y 3m

TABLE 2  
**Result of the Practical Test**  
N=225

Process skill	Mean	SD	Maximum possible score	Percentage score
Graphing data	1.54	1.03	3	51.3
Determining relationship	1.36	1.04	4	34.0
Interpretation	1.04	0.93	3	34.7
Prediction	0.12	0.32	1	12.0
Formulating a generalization	0.56	0.50	1	56.0
Whole test	4.62	2.40	12	38.5

### **Result and Discussion**

Table 2, 3 and 4 summarize the results of this study. Table 2 presents the mean score obtained by the students in various process skills assessed in this study. It is seen that only in two skills i.e. graphing data and formulating a generalization, the average score is more than 50%. The average score in determining relationship is 34.0% and in the interpretation skill, it is 34.7%. The minimum score is found in the prediction skill — it is only 12%. This implies that students found the items of the task testing the prediction skill most difficult. Table 3 presents the achievement of boys and girls in the test. The last

column gives the critical ratio calculated to see the gender difference in the process skills under consideration. It is seen that in the whole test, gender difference is statistically not significant — only in the prediction skill, the gender difference is found to be statistically significant at 0.01 level. In fact, in graphing skills, the average score of boys and girls are found to be equal. In the process skills of determining relationships, interpretation and prediction, the average score of boys is more than girls. But in the skill of formulating a generalization, the average score of girls is little more than that of boys although this difference is statistically not significant.

TABLE 3  
**Achievement of Boys and Girls in the Practical Test**

Problem or skill	Boys Mean	N=162 SD	Girls Mean	N = 63 SD	Maximum possible score	Critical ratio
Graphing data	1.54	1.01	1.54	0.96	3	0
Determining relationship	1.43	1.13	1.19	0.66	4	1.97
Interpretation	1.13	0.92	0.81	0.91	3	2.35
Prediction	0.13	0.34	0.08	0.27	1	3.47*
Formulating generalization	0.56	0.50	0.59	0.49	1	0.41
Whole test	4.78	2.44	4.21	0.38	12	1.60

\* Significant at 0.01 level

Table 4 gives the difference in achievement in the test among schools. In the whole test, the average score varies from 3.74 obtained in a government school to 6.0 obtained in a private school — the variation is 60.4%. In other skills (excluding prediction), the variation ranges from 66% to 93%. In the prediction skill in which while the average score is as low as .12 variation is 500%. Though there is variation in achievement of students from school to school, but a definite pattern showing correlation between school and achievement of its students does not emerge from this study. In fact, investigation into this aspect requires a separate and detailed study taking into consideration explicitly different variables of the school environment and is not the aim of this study.

### **Implications**

This study has raised serious concerns for science educationists, curriculum developers and Boards of Secondary Education in India. It clearly shows that the

presently used curriculum of physics practical has failed to develop the analysis and interpretation skills in students up to a reasonable level. An analysis of the currently used physics practical curriculum shows that the two main reasons for this poor performance are (1) the type of laboratory exercises used in the coursework, and (2) the nature of assessment presently in practice. It is high time that curriculum designers and developers, Boards of Secondary Education take a fresh look at the following elements of the curriculum (1) Instructional Approach, (2) Laboratory exercises, and (3) Assessment of practical work in physics. The author is presently developing a new approach to practical physics which will address to all the three elements of the curriculum mentioned above and will be based on recent advances in the field of Cognitive Science, in general and Tamir's taxonomy of practical skills in particular.

### **Acknowledgements**

The author is grateful to Prof. A.K.

TABLE 4

### **Differences in Achievement in the Practical Test among Schools**

Process skill	School C1 N=25		School C2 N=50		School C3 N=23		School P N=34		School G1 N=46		School G2 N=22		School G3 N=25	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Graphing data	1.28	0.96	1.22	1.10	1.43	0.93	2.09	0.78	1.37	1.01	1.91	0.99	1.76	0.95
Determining relationship	1.56	1.10	1.08	1.06	1.96	0.85	1.62	1.07	1.11	0.94	1.36	1.07	1.32	0.73
Interpretation	1.21	0.89	0.84	0.90	1.17	0.87	1.47	0.85	0.78	0.92	1.36	0.78	0.76	0.99
Prediction	0.08	0.27	0.08	0.27	0.30	0.46	0.18	0.38	0.07	0.25	0.05	0.21	0.12	0.32
Formulating a generalization	0.56	0.50	0.58	0.49	0.57	0.50	0.65	0.48	0.41	0.49	0.68	0.47	0.60	0.49
Whole test	4.68	1.95	3.8	2.63	5.43	2.68	6.0	2.05	3.74	2.15	5.36	2.04	4.56	2.21

Sharma, Director, NCERT who interested me in this field three years ago. The author thanks Prof. A.N. Maheshwari, Joint Director, NCERT and Prof. K.V. Rao, Former Head, Department of Education in Science and Mathematics, and Prof R.D. Shukla, Head, DESM, NCERT for their encouragement and interest in

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## APPENDIX

### **Task 1**

25 min.

Air enclosed in a hypodermic syringe was compressed in steps keeping temperature of the air constant. Data of the experiment is given in the following table:

Volume, V (cm <sup>3</sup> )	60	50	40	30	20	10	5
Pressure, P (absolute atm)	1.00	1.13	1.43	1.98	3.00	5.88	11.48

1. Using the above data, plot the pressure v/s volume on a Cartesian graph paper.
2. Suggest a relation which best describes the variation of P with V in this experiment. Can you confirm this relation using the above data.  
.....  
.....
3. Would you expect air to follow the above relationship under extremely high pressures ? Give reasons for your answer.  
.....  
.....

### **Task 2**

A stone was dropped with initial velocity of zero and its distance (s)- time (t) data was collected. This data was used to draw distance-time graph (Fig. 1) and distance - time<sup>2</sup> graph (Fig. 2) for this motion.

Study the two graphs carefully and answer the following questions:

1. Is the stone moving with a constant velocity ? State reasons for your answer.  
.....  
.....
2. Is the stone moving with a constant acceleration ? State reasons for your answer.  
.....  
.....
3. (a). How s varies with t<sup>2</sup>?  
.....

(b). Determine a relationship between  $s$  and  $t^2$ .

.....

4. Can you obtain the value of acceleration due to gravity, 'g' from the above relationship ? If yes, calculate the value (Show all calculations).

.....

5. Write a general equation which describes such motions.

.....

Distance versus time

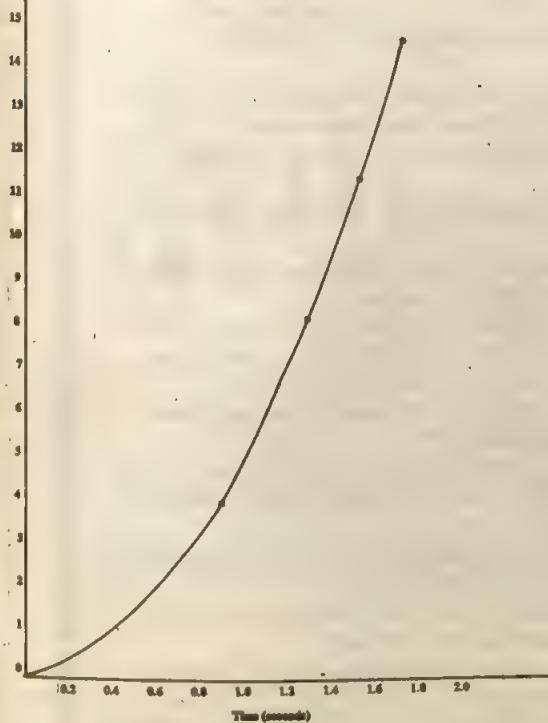


Fig. 1

Distance versus  $t^2$

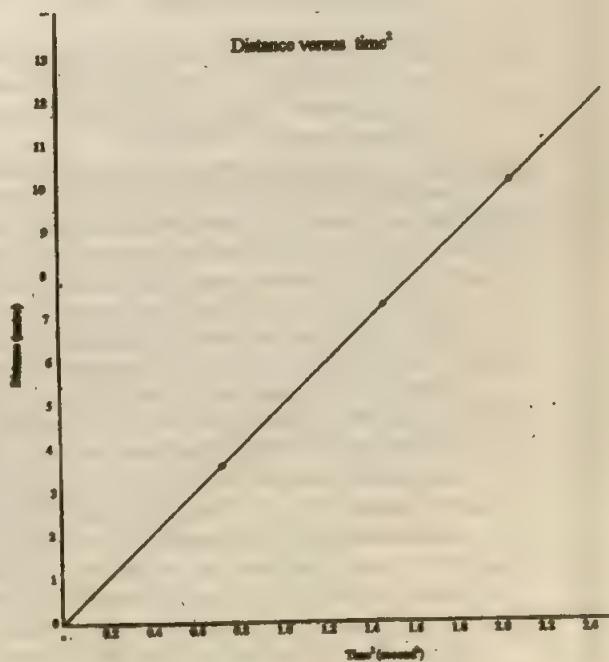


Fig. 2

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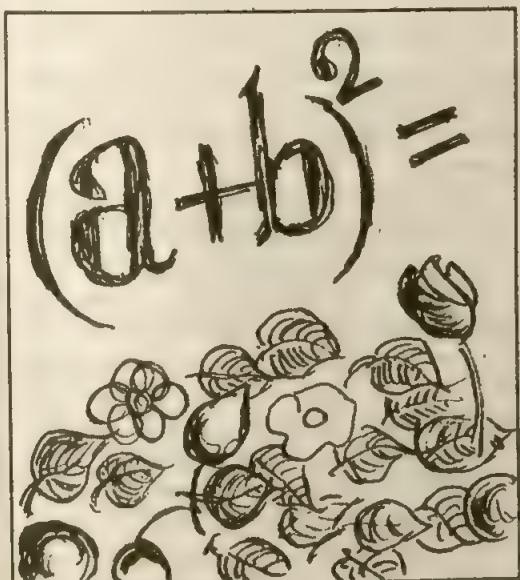
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# Teaching of Mathematical Concepts at Upper Primary Stage

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nderstanding of concepts is basic to further learning, transfer and problem solving. It involves more than definition of a con-

cept or recognition of common examples. A student should also be able to represent or recognize a concept in different modes of representation or its application in different settings, translate from one mode to another, generalize to other examples, recognize its non-examples and explain why, abstract its properties other than those used in its definition, compare and contrast concepts and integrate concepts. These need to be emphasized in teaching, learning and evaluation for attainment of higher level objectives such as transfer and problem solving. In this paper we elaborate on these for teaching of mathematical concepts, at upper primary stage only. As teaching of concepts depends on the content, the developmental stage of the learner and his previous experiences, we would mainly emphasize activities which are feasible in Indian setting.

## *Developmental Stage of the Child*

Piaget suggested four stages in development of the child: sensori-motor before appearance of language at about two years of age, pre-operational which precedes real operations about 2-7 years, concrete-operational about 7-12 years of age and formal-operational at twelve plus. Further experiments and research has suggested that characteristics suggested by Piaget for the formal operational stage do not begin to emerge until 14 or 15 years of age in many pupils. These suggest that most pupils at upper primary stage are at concrete operational stage and there is a need for concrete referents in teaching of mathematics. It does not imply that mathematics teaching always re-

quires concrete apparatus till the full emergence of formal operations. It can be replaced by actions carried out in the mind on the basis of prior knowledge underlying concrete manipulations.

### ***Previous Experience***

Mathematics learning largely consists of building understanding of new concepts onto previously understood concepts. There is thus a need to check students understanding of concepts which are prerequisites for learning of the new concepts. Children at the end of primary stage are expected to have understanding of the concept of place value and zero as a place holder for reading and writing of whole numbers; four fundamental operations on whole numbers, fractions and decimals; percentage; geometrical shapes like circle, triangle, square, rectangle; line segment, line, ray and angle; measurement of length, angles, capacity, time and temperature. However, tests given at the beginning of Class VI by the author in Delhi government schools reveal lack of adequate understanding of these by most students. There is thus a need to assess understanding of these and take remedial measures before teaching topics for which these are prerequisites.

### ***Empirical Reality in India***

In most schools in India it would not be possible to use commercially produced concrete materials for individual students, videotapes or projectors. However, it is not a great handicap. Activities requiring use of simple concrete materials like ropes, matches, paper cutting, paper folding, drawing on geopaper, graph paper can be used by

individual students. Demonstration aids like models, charts, drawings can be used to provide visual experiences for abstracting a concept and its properties. Teachers can also draw students attention verbally to objects in the environment or situations in daily life which model the concept and ask them to answer questions which would enhance understanding of the concept.

### ***What is a Concept ?***

It is difficult to define a concept and we would not delve into it. We may think of a concept as formation of an idea or mental image which is labelled by a word or symbol. Skemp (1986) distinguishes between two types of concepts primary and secondary. Concepts which are abstracted from sensory or motor experiences are called primary concepts and concepts which are abstracted from other concepts are called secondary concepts.

The mental image for primary concepts is first formed by having sensory or motor experiences of an object/set of objects, its attributes or relations between an attribute/attributes of two or more objects e.g. concept of number "four",  $>$ ,  $=$ ,  $<$ ,  $7+8$ ,  $3 \times 4$ , line segment, angle, triangle, circle, length, area, symmetry, congruence, similarity. These are then expressed by a word or symbol. After a number of experiences, these are abstracted and become an element of thought detached from concrete reality. Some concepts may later be left undefined e.g. concept of a point, line and plane or defined in terms of other concepts e.g. concept of a circle may first be formed by having sensory experiences

and later may be defined as a figure formed by a set of points in a plane equidistant from a fixed point.

Secondary concepts are derived from other concepts in a number of ways :

- by extending a concept to a more inclusive concept called super concept e.g. whole numbers to integers.
- generalizing a concept e.g. generalisation of arithmetical numbers as a literal number, a class of relations "equivalent to" which encompass equal to, congruence, similarity with class properties of reflexivity, symmetry and transitivity.
- differentiating a concept into sub-concepts called coordinate concepts (Merril and Tennyson, 1977) by restricting measures of some attribute to certain range of values e.g. differentiating angles into acute, obtuse and right angle etc. or relations between measures of some attributes e.g. triangle into scalene, isosceles and equilateral triangles.
- comparing an attribute/attributes of two or more objects e.g. larger than, equal to, smaller than, fraction, ratio, percentage, congruence and similarity of geometrical shapes, measure of an attribute.
- a rule relating two or more concepts e.g. chord of a circle is a line segment which connects two points on a circle or factor of a number is a number which divides it exactly.
- transforming a concept by doing something to it e.g. multiplying a number itself n times to get its  $n^{\text{th}}$  power.

### ***Understanding of Concepts***

A student understands a concept if he is able to

- label or define a concept
- represent a concept in many ways or apply it in many situations
- translate a concept from one mode of representation to another.
- recognize its examples in which many variable features vary or give new examples or generate examples with specified properties.
- recognize its non-examples and explain why.
- abstract its properties other than those used in defining it.
- compare and contrast concepts by recognizing similarities and differences between sub concepts of a concept and inclusive relations between a concept and its super concept.
- integrate concepts with previously learned concepts.

All of these may not be relevant or important for a concept depending on its nature, newness, complexity and stage of learning of the student.

### ***Teaching of Concepts***

Teaching of concepts for understanding needs to be planned carefully analyzing it for prerequisites or sensory experiences that would enable students to abstract a concept; the examples and non-examples that should be used to enable students to generalize to other examples in which variable attributes vary and discriminate it from non-examples in which a critical feature is missing; deciding on activities which would help students in abstracting its properties, deciding on concepts to which it should

be compared or contrasted from or be integrated with assessment of its understanding and review while teaching other concepts based on it or topics to which it can be applied.

### ***Introducing a Concept***

We need to ensure that students have the prerequisites of a concept before labelling or defining a concept. Pre-requisites of a concept depend on its nature.

Sensory motor experiences need to be provided for formation of primary concepts e.g. angle, circle, area, volume, symmetry, congruence. A large number of experiences are necessary for formation of such concepts and their abstraction as elements of thought detached from concrete reality. Experiences may be provided by engaging students in activities involving use of manipulatives, visual experiences by means of videotapes, charts, models, drawings or drawing their attention to familiar objects in the environment before identifying a concept by a label or symbol. These are crucial for language to make sense.

Secondary concepts should first be analyzed to understand its contributory concepts and for each of these its contributory concepts and so on till we reach the experiences or concepts which students can be assumed to have had or understand adequately. These need to be reviewed or assessed before introducing a concept based on these depending on time gap in their teaching and complexity. For example, concept of prime number is taught just after the concept of a factor, only a review with examples emphasizing special

cases e.g. one and number itself as a factor of every number may be all that is necessary. But, before introducing the concept of a rational number, a quizz may be desirable on its prerequisites viz. fractions and integers which were taught long ago and are more difficult.

Algebraic concepts at upper primary stage which are generalizations of arithmetical concepts of number and operations on them need to be preceded by activities which facilitate transition to algebra. Activities which require students to generalize from patterns, think about a numerical relations in a situation from many examples, discuss it in everyday language and finally represent it with letters or notation like  $\square$  and  $\Delta$ , teaching arithmetical numbers in ways which enhance their understanding and generalize to more general concepts e.g. concept of area models for multiplication of numbers which generalizes to literal numbers and their combinations with numbers. For description of some such activities see Davis (1985), Kieran, Battista and Douglas (1991), Peck and Jeneks (1988), Pegg and Redden (1986).

### ***Representation of a Concept***

A concept should be presented in many modes or settings to enhance its understanding and develop conceptual schemes helpful for further learning.

Bruner (1966) suggested three modes of representation of mathematical concepts inactive (physical representation), iconic (pictorial representation) and symbolic (written symbols). Lesh and Landau (1983) expanded it into five

— real world situations, manipulatives, pictures, spoken symbols and written symbols.

Desirable modes of representation for a concept would depend on its nature, newness, complexity and previous experiences.

It is desirable to represent complex and new concepts in many modes to enhance its learning and further learning based on it. For example a fraction like  $\frac{2}{5}$  may be represented as two parts of a cake which has been divided into five equal parts, on a number line, constituting two parts of a rectangle which has been divided into five equal areas or four coins of a picture of a collection of ten coins or picture of  $\square$ s or  $\square$ s so arranged in two rows of five each or division of number two by five and may also be written as two-fifths. Similarly concept of a parallelogram may be represented by its model, pointing to its examples in the environment, drawing it on the blackboard, engaging students in activities like drawing it on geopaper, graph paper, making it by arranging two congruent triangles together.

Simple secondary concepts may be represented by pictures and verbally if students have adequate mastery of contributing concepts e.g. concepts like prime numbers, chords of a circle, diagonals of a quadrilateral.

New representations for already familiar concepts may be introduced which are useful for more inclusive or general concepts e.g. representation of natural numbers on a number line which can later be used for integers, fractions, decimals, rational numbers or use of area models for multiplication of natural numbers which can later be

used for multiplication of fractions, decimals and literal numbers and sum or difference of literal numbers or literal numbers and natural numbers.

#### ***Translation of a Concept Given in One Mode to Another***

Translation of a concept expressed in one mode to another besides enhancing understanding is an important capability needed in day-to-day life e.g. writing of amount of money in words and figures, interpreting or reading tables and graphs given in ready reckoners, newspapers, books etc. It is also an important aspect in applications and problem solving which invariably require translating a word problem into a mathematical sentence, table or diagram. Many opportunities and activities should be provided to students to translate from one mode to another. Questions or activities like the following may be used:

- write a given amount of money in words and figures.
- represent and read whole numbers, integers, rational numbers on a number line.
- represent and read multiplication of whole numbers, fractions, decimals and literal numbers as areas on a geo or graph paper.
- translate word problems involving fundamental operations or numbers in arithmetical sentences.
- make equilateral, scalene or isosceles triangles using matches.
- draw geometrical concepts like parallel lines, triangles, parallelograms on geo paper, graph paper, with a ruler.
- translate an expression given in

- words in an algebraic expression.
- translate a word problem onto an algebraic equation.
- draw and read graphs.
- read tables to find specific information.
- measure perimeters of irregular figures.
- draw a cuboid, cone, right circular cylinder and label its dimensions.
- express formulae for perimeters, areas, volumes of regular geometrical shapes given in words in symbols and vice versa.
- draw regular figures with given perimeter or area.
- give directions for copying simple figures on a paper to someone who cannot see the figure himself.
- draw and read maps of reaching school from different points nearby.

### ***Use of Examples***

Many characteristics vary among class members of a concept these are called variable attributes. It is important to give many examples in which variable attributes vary. So that students can generalize to other examples. For example in teaching concept of a triangle models or drawings that vary in size, orientation, length of sides and angles should be presented. Many students who have only seen squares with sides parallel to the edges of a textbook or blackboard, cannot recognize squares like  $\diamond$  or draw a square on the hypotenuse of a right angled triangle whose legs are parallel to the edges of a paper. The students may also be asked to give examples from the environment to which other students can react.

The students may be asked to gen-

erate examples of concepts with which they have previous experience using analytical thinking. Questions or activities such as the following may be used:

- write all possible numbers, smallest number, largest number using specified digits (using each digit once only).
- write numbers which are 1 more or less than a number with special emphasis on numbers which end in nines or zeros.
- generate stories in which specific computations such as

$$2150 \times 1.5, \frac{1}{2} \times \frac{2}{3}, \frac{1000 \times 5 \times 2}{100}$$

are required.

- write two numbers whose LCM is 12.
- write two numbers whose HCF is 1.
- make a cuboid using 24 unit cubes.
- make triangles giving specified numbers of matches and describe how many different triangles can be made and their type.

### ***Characterization of a Concept***

A concept is characterized by attributes that all members of a class possess. These are called critical attributes. Students attention may be drawn to these by listing them and/or providing practice on examples in which a critical feature is missing so that they can discriminate non-examples from examples. Questions like the following may be asked.

- Which of the following are not prime numbers? Place an X against them and explain why.  
1, 2, 4, 7, 9
- Name the property that prevents the

following from being called a square.



- Students gave the following examples of a triangular object : open compass, samosa, mountain. Why, are these wrong ?
- For each of the following, place an X against unlike terms and explain why ?
  - 6x and x
  - $x^2$  and  $2x$
  - $2x$  and  $2y$
  - xy and yx

### ***Exploration of Properties of a Concept***

A concept has many properties other than those used in defining it. The students may be asked to explore these by observation, measuring, paper cutting and folding, rotation about a point or analytical thinking. Questions or activities such as the following may be provided and answers of different students discussed in class.

- asking the number of sides, diagonals, vertices and angles in different types of polygons.
- measuring angles of different triangles, quadrilaterals and finding their sum.
- drawing triangles with specified angles including set of angles for which the figure cannot be drawn (with sums greater than 180).
- making triangles using sticks of specified length including a set of sticks with lengths for which a triangle cannot be made.

- exploring the properties of quadrilaterals. For example, a parallelogram by measuring its sides and angles, cutting it along the diagonal and comparing the triangles or making a rectangle from it by a suitable cutting and rearranging it.
- finding lines of symmetry by cutting and paper folding.
- making models e.g. a cuboid using 24 unit cubes or open boxes by cutting corners from same sized grid papers and showing these in class for observation of properties.
- estimating measurements or answers to computations involving fundamental operations.

### ***Comparison and Contrast of Concepts***

A concept should be related to superordinate concepts which may have been formed by extending it and discriminated from co-ordinate concepts which may have derived from it. Questions pertaining to following may be asked :

### ***Compare Different Examples of a Concept***

- Compare the following by writing appropriate symbol,  $>$ ,  $=$  or  $<$  in

61	<input type="checkbox"/>	16,	.5	<input type="checkbox"/>	$\frac{1}{2}$ ,	$\frac{1}{6}$	<input type="checkbox"/>	$\frac{1}{5}$
-2	<input type="checkbox"/>	-4,	.333	<input type="checkbox"/>	$\frac{1}{3}$ ,	$\frac{2}{3}$	<input type="checkbox"/>	$\frac{3}{5}$
.5	<input type="checkbox"/>	$\frac{15}{100}$ ,	$\frac{12}{16}$	<input type="checkbox"/>	$\frac{3}{4}$			

- Find the largest/smallest angle, length, area, volume given examples of two or more of these.

### **Discriminate Examples of a Concept from Non-examples of Coordinate Concepts**

Which of the following variables are inversely related, place a ✓ against them.

- amount of commodity and its cost.
- number of persons employed to complete a work and time taken to finish it.
- speed of a car and distance it would travel in a specific time.
- speed of a car and time taken to cover a specific distance.
- Number of similar towels hung in sunshine and time taken to dry them.

In what way are a rectangle and square (a) similar, (b) different.

In what way are an equilateral triangle and square (a) similar, (b) different.

Which of the following are like terms, place a ✓ against them :

2x, 3x  
5x, 5y  
x, 2x  
xy, yx

Which of the following are true for all values of x, place a ✓ against them

- $x+3 = 5$
- $2(x+1) = 2x + 2$
- $x \times 0 = 0$
- $2x + 3 = 3x + 5$
- $(x - 2)^2 = x - 4x + 4$

### **Recognize Inclusive Relations between Concepts**

Is any whole number an integer ?

Is any parallelogram a rectangle ?

If no draw such a parallelogram ?

For following numbers, write W for whole numbers, I for integers, F for fractions, D for decimal numbers and R for rational numbers. More than one of these may be applicable, write all of them.

$\frac{1}{2}, .54, -3, 7, 0, 1, .333\dots, 49422422\dots$

Name different types of quadrilateral for which the following properties are true using Q for any quadrilateral, S for a square, R for a rectangle, Rh for a rhombus, P for a parallelogram and T for a trapezium. More than one of these may be correct, write all of them.

- one pair of opposite sides are parallel.
- both pairs of opposite sides are parallel.
- opposite angles are equal.
- all sides are equal.
- all angles are right angles.
- both pairs of opposite sides are equal.

### **Integration of Concepts**

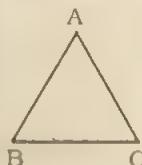
A systematic review of concepts can be built in by integrating concepts with concepts learned earlier which enhances their retention and understanding.

### **Provide a Review of Concepts Learned Earlier**

Give as many situations as you can where a person needs to use percentage.

For the adjacent figure

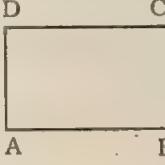
- name all the angles
- name all the line segments
- measure the length



of all line segments.

(d) measure all the angles using a protractor

ABCD is a rectangle



(a) name a pair of parallel lines

(b) name a pair of perpendicular lines

Give all the properties of a square (different answers may be desired at different times, e.g. after teaching of the concepts of congruence, symmetry). Integrate it with concepts in other topics.

If the sides of a square are increased by 10%, what would be the percentage increase in its (a) perimeter, (b) area.

If the length of edge of a cube is doubled, how would its volume change.

Sides of a triangle are in the ratio 1: 2: 3 and its perimeter is 24 cm. Find the sides.

Find the cost of tiling a floor whose length and breadth are 4 and 3 metres respectively. The cost of tiling it is Rs. 90 per square metre.

Which of the following variables are directly proportional? Place a ✓ against them.

(a) circumference of a circle and its radius.

(b) area of a circle and its radius.

(c) length of an arc of a circle and angle subtended by the arc at the centre.

(d) area of sector of a circle and angle subtended by the sector at the centre.

Cut a rectangle along the diagonal and rearrange the triangles with

equal sides adjacent to each other, trace it on a paper.

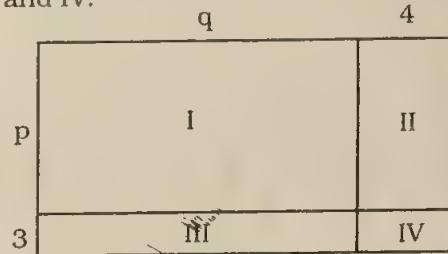
(a) How many figures can you get by rearranging the pieces?

(b) Name them.

(c) Can you tell without measuring which will have the smallest perimeter, largest perimeter?

(d) Can you tell without actual measuring which would have largest area, smallest area?

For the figure given below, represent its area (a) in terms of length of its sides (b) as sum of areas of I, II, III and IV.



Represent  $(a+b)$   $(a+b)$  by a diagram and show that  $(a+b)^2 = a^2 + 2ab + b^2$

Write a paragraph on how mathematics is useful to a person in his day-to-day life.

Write a paragraph on how mathematics is useful to a shopkeeper/farmer/house wife.

#### ***Assessment of Understanding of Concepts***

Understanding of concepts needs to be emphasized in testing to motivate students to pay attention to it, and learn from it. The tasks for assessment should differ from those used in teaching to ensure they are testing understanding and not memory e.g. asking students to define in their own words

or recognize paraphrased definitions, using examples and non-examples different from those used in teaching, abstract properties of different concepts by using similar techniques etc.

It is not necessary to assign separate tasks to assess each aspect of understanding. It is advisable to design a single task that covers several aspects. It is also not necessary to assess all aspects or all students or formally by a quiz or test at all times. Problems at different levels of involvement and for a small group or whole class can be created. Exploration of properties of concept can be done in small groups.

The aspect of conceptual understanding to be tested should be selected according to previous experience and developmental level of students. Further these should be consistent with meth-

ods of teaching.

In monitoring students understanding of concepts a distinction may be made between concepts or aspects of concepts for which mastery should be the aim, e.g. concept of coefficient of a term, like terms, power of a literal number etc. and adequate mastery of concepts which develop over time, can be extended further and large individual differences have been observed in ages at which they are mastered, e.g. concept of place value, fundamental operations on numbers.

### ***Review of Concepts***

Concepts would be retained only if they are reviewed systematically while teaching concepts based on them and providing opportunities which require their application while teaching other topics.

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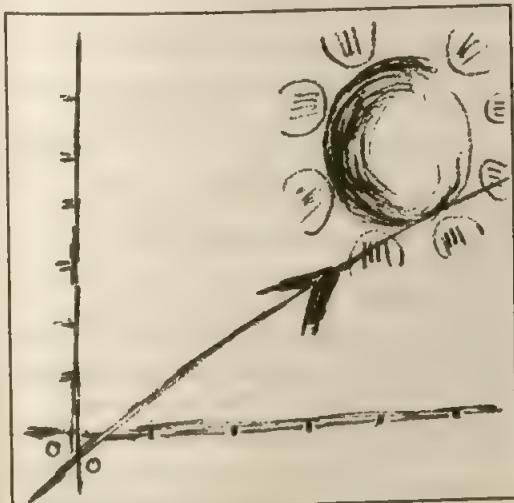
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# **Scientific Attitude and Its Relationship with Academic Achievement at Higher Secondary Level**

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**T**

The time has come when science is going to be an indispensable part of our life and

living styles in the rural as well as urban sectors and therefore, scientific outlook will be essential for all members of the society to get rid of a number of irrational and superstitious belief, dogmas and faith in obscurantism. As such, a rational and just society requires development of scientific temper among individuals, especially among the adolescent learners for progressive growth and modernisation. All well flourished and flourishing civilizations of the world, in this way, may be designated as the brain children of the mankind possessing scientific attitude and inventive curiosity. It is true to say that the scientific way of looking at things and thinking logically as well as independently on any problematic situation, may enable one to find out desired solution while marching ahead on the path of innovation and exploration. Through this process one may be educated in true sense. Since education aims to bring rationality in thinking and power of judgement among human beings, all our educational endeavours eventually are concerned with inculcation of an ability to think logically and develop skills desirable to make scientific observation and analysis in life among the young learners, so that they may be able to avoid ragged traditions and use scientific deduction to solve the various problems of their own life as well as of the society.

In this way, science may become a way of life and enable individuals and societies to cope with the problems likely to arise in science dominated future due to its significant role in the field of inventions and innovations, discovery of new facts and truths, for ex-

plaining and elaborating old facts and findings in a new way, analysing causes behind natural and supernatural phenomena, finding out solutions to the ever increasing problems of human life especially on account of narrow feelings and selfishness, searching out probable solution of the problems of resource crisis and environmental pollution as well as degradation of social and life-style norms and values etc.

All these and similar innumerable problems are imposing a great challenge before the unity and integrity of mankind as well as existence of human race. To face these challenges with courage and vigour, development of rational outlook and scientific attitude seems to be of supreme importance.

Science as a process, adopts a specific mode of enquiry through the scientific method which combines the inductive and deductive thought processes, synthesis of observational fact and figures with reasoning and analysis for purposeful fact finding as well as verification of the presuppositions. At the same time, as a product, it forms a systematised body of knowledge obtained through a series of a large number of empirical observations, but in the both forms, the fundamental part and functionality is scientific attitude.

Thurstone (1929) defined attitude as the sum total of man's inclination and feelings — prejudices and biases, pre-conceived notions, ideas, fears, threats and convictions about any specific topic. The behavioural part was added in this definition later on. Allport (1935) stated it as a neutral and natural state of readiness, organised through experiences, exerting a directive or dynamic

influence upon individual response to all objects and situations with which it is related.

Doob (1947) considered it as a bipolar concept, since two people may feel the same amount of effect towards an object but may behave differently or may have different belief.

Cheim and Evans (1948) discussed over the issue further and took it as a multidimensional concept. Equal favourability and cognition may not cause equal belief and action. Thus besides cognition, belief and behaviour are the other dimensions of attitude. As such, the attitude concerned with science, scientific method and temperament, analysis etc. may be stated as scientific attitude.

Dictionary of Education (1972) defines Scientific Attitude as a set of emotionally toned ideas about science and scientific method and related directly or indirectly to a course of action. In the literature of science education, the term implies such qualities of mind as intellectual curiosity, passion for truth, respect for evidences and appreciation of the necessity of free communication in science.

Therefore, scientific attitude is invariably concerned with open mindedness, desire for accurate knowledge, confidence in the procedures for seeking knowledge and having a faith in the use of verified knowledge to fetch solution of the problems, rationality, curiosity, objectivity, aversion to superstitions etc., the conceptual criteria, in terms of which academic development may also be elaborated.

Jain (1967) while constructing a scientific attitude scale for Indian youth,

selected four domains of intellectual, affective, connective and metaphysical and psychological abilities which to some extent are all concerned with power of expression, knowledge-application, communication, socialisation and commitment to acquire knowledge in spite of problems, the basic dimensions of academic attainment.

Here, intellectual domain is related with belief in cause and effect relationship, searching sufficient evidence and data to come to a conclusion and arousing intellectual curiosity. The affective domain is concerned with respecting others in data, production and its verification, preparedness to share findings with others and believing in goodness of inventions. Similarly, the connative aspect is related with intellectual honesty, testing logical conclusions and withholding judgement till its further verification. The metaphysical and psychological domain is related with freedom from superstitions, prejudices and fatalism.

Considering the aspects and domains of the two concepts, they seems to be related internally but now a days, since a set of marks obtained by a student in a certain examination is often taken as an indicator of academic achievement, establishment of relationship between the two variables with a certain degree of confidence become essential, so that instead of academic achievement scores, if desired, test of scientific attitude could be included in all admission and selection tests to assess even those applicants for admission who have not scored a certain percentage of marks in aggregate as well as in the science subjects in the last qualifi-

fying examinations. This may help to avoid the dilemma of existing double testing norms.

Considering the above rationale, the objectives of the study were finalized in the following pattern:

### **Objectives**

To find out:

0. 1= Correlation between cognitive domain of scientific attitude and academic achievement of higher secondary students.
0. 2= Correlation between affective domain of scientific attitude and academic achievement of higher secondary students.
0. 3= Correlation between psychomotor domain of scientific attitude and academic achievement of higher secondary students.
0. 4= Relative contribution of cognitive, affective and psychomotor domains of scientific attitude towards academic achievement of higher secondary students.

On the line of above objectives, the following hypotheses were framed in null form for verification.

### **Hypothesis**

There is no significant correlation between:

- Ho.1= Cognitive domain of scientific attitude and academic achievement of higher secondary students.
- Ho.2= Affective domain of scientific attitude and academic achievement of higher secondary students.
- Ho.3= Psycho-motor domain of sci-

tific attitude and academic achievement of higher secondary students.

**Ho.4=** There is no significant contribution of cognitive, affective and psychomotor domain of scientific attitude towards academic achievement of higher secondary students.

The study was delimited on the grounds of urban higher secondary male students. The students studying at first year (Class XI) of recognised higher secondary schools and intermediate colleges situated in the urban area of Varanasi city were included in the study sample. The schools were selected randomly and the students who have opted science were specifically taken into consideration. For measuring academic achievement, the marks obtained by the students in their secondary (or high school) examination were taken into account.

The ex-post facto design was decided to be used, as in this study, instead of creating or manipulating the treatments, effect of a naturally occurring treatment was to be observed and examined, especially in terms of relationship between the two variables under observation.

#### **Sample**

The study sample consisting of the

higher secondary students was selected accidentally, out of five randomly selected schools. A sample of 120 male students found present in the class during data collection period were selected for the purpose of investigation.

#### **Tool**

The Scientific Attitude Scale (Psychomotor, Affective, Cognitive Questionnaire) developed by Singh (1988) was selected to measure the scientific attitude of the students.

#### **Data Collection**

The Scientific Attitude Scale was administered personally and the responses obtained were scored using the prescribed scoring key. After preparation of the master chart, the concerned achievement scores of the students in their high school examination were compiled on the chart and relevant parametric statistical measures were computed.

#### **Results and Discussion**

The results obtained were analysed objective wise and the levels of significance etc. is presented in the Table 1.

The Table 1 represents the value of  $r=0.756$  as obtained between the cognitive domain and academic achievement of the higher secondary students which was found significant at .01 level

TABLE 1

#### **Relationship between Cognitive Domain of Scientific Attitude and Academic Achievement**

Variables	N	Coefficient of Correlation	Level of Significance
Cognitive Domain Academic Achievement	120	$r=0.756$	Sig. at .01 level

of confidence. Therefore, the null hypotheses ( $H_0.1$ ) according to which there is no significant correlation between the cognitive domain of scientific attitude and academic achievement, stands rejected.

This indicates that both the variables are related with each other and as such those who scored better in the cognitive domain of scientific attitude, may also achieve better academically. In other words, development of the cognitive domain of the scientific attitude may help in higher achievement in academic disciplines to the students of higher secondary level.

Similarly, the relationship between the other domains of scientific attitude and academic achievement were also obtained. The relationship with affective domain is presented in the Table 2 below:

The Table 2 also indicates that the Academic Achievement and affective domain of scientific attitude is corre-

lated significantly because the value of  $r$  thus obtained is as high as to be significant at .01 level of confidence. Therefore, the null hypotheses ( $H_0.2$ ) which states that there is no significant correlation between the affective domain of scientific attitude and academic achievement, stands rejected.

This also obviously clarifies that the two variables are highly correlated with each other and thus the higher academic achievement of the students may be considered as the indicators of better scientific attitude in terms of its affective domain.

In the same way, an attempt was made to determine the correlation between the psychomotor domain of scientific attitude and the academic achievement of the higher secondary students and the results thus obtained is presented in the Table 3.

The results produced in the Table 3, indicates the product moment coefficient of correlation between the psychomotor domain of scientific attitude

TABLE 2  
**Relationship between Affective Domain of Scientific Attitude and Academic Achievement**

Variables	N	Coefficient of correlation	Level of Significance
Affective Domain	120	$r=0.770$	Sig. at .01 level
Academic Achievement			

TABLE 3  
**Relationship between Psychomotor Domain of Scientific Attitude and Academic Achievement**

Variables	N	Coefficient of correlation	Level of Significance
Psychomotor Domain	120	$r=0.773$	Sig. at .01 level
Academic Achievement			

and academic achievement of the students at higher secondary level which is as high as to be significant at .01 level of confidence. Thus, the null hypothesis ( $H_0.3$ ) in which it was recorded that there is no significant correlation between psychomotor domain of scientific attitude and academic achievement, stands rejected.

This table also indicates the high positive relationship between these two variables. Since, all the three domains of scientific attitude are found highly correlated with academic achievement in a positive way, it could safely be concluded that development of the scientific attitude among the students studying at higher secondary level may necessarily facilitates better academic achievement.

Such a result is in tune with the findings of Golwalkar (1978) who had obtained similar type of relationship in science subjects. Baker (1985) in contrary, found that the middle school students with A and B grades in science had developed a negative attitude towards science whereas those with C and D grades had a more positive attitude. He suggested two possible reasons for such unexpected results: (i) higher ability middle school students may have found science as a boring one, which has adversely affected their attitude, and (ii) the sci-

entific attitude inventory may not be valid for the middle school students as they perhaps could not follow the items well. At the same time, it is also possible that their scientific attitude may not develop well at this stage. To avoid such of a situation, the higher secondary students were selected so that they may possess well developed scientific attitude and also be able to follow the items of the scientific attitude scale. They at this stage, must be much critical minded, respectful to the evidences, honest, objective in decision making, open-minded and with enquiring mood which are also the qualities essential for better academic achievement. This may be a strong reason of obtaining a high, positive and significant relationship.

To determine the relative contribution of the cognitive, affective and psychomotor domains of scientific attitude towards academic achievement, multiple R and  $R^2$  were computed. The Table 4 shows the results thus obtained.

The Table 4 shows that all the three domains of the variable of scientific attitude contribute as much as 67.50% of variance towards academic achievement, which may be considered as a high contribution. As such, it could be stated that the scientific attitude contributes highly over the academic

TABLE 4

**Relative Contribution of Cognitive, Affective and Psychomotor Domains of Scientific Attitude towards Academic Achievement**

N	Multiple R	$R^2$	Percentage of Contribution
120	0.823	0.675	67.50

achievement of the students studying at higher secondary stage. Therefore, the null hypothesis (Ho.4) according to which there is no significant (relative) contribution of cognitive, affective and psychomotor domains of scientific attitude towards academic achievement of higher secondary students, stands rejected.

Any percentage of contribution beyond sixty, may not be taken as insignificant one. On this ground, the hypothesis has been taken as rejected.

### ***Interpretation***

The results thus obtained, evidently makes it clear that the two variables under study are related with each other positively, and scientific attitude contributes significantly towards a remarkable and higher portion of academic achievement. Rani (1986) obtained such a variance relatively much lower in case of female science students in relation with their cognitive developmental level, ranging between 30 and 55% only. Baker (1985) found 56 to 67% of variance concerned with attitude to science achievement in middle schools. Thus, the results obtained is an expected one and in tune with the fore runners, especially on account of the commonalities between the two variables as stated earlier.

### ***Implications***

The study implies that on account of high positive correlation between the two variables, it seems to be inevitable to develop better scientific attitude among school going population for their better academic performances. This is possible through making science edu-

cation much more attractive and interesting for them. Development of popular science educational packages, use of various modes and channels of communication, practising various models of teachings suitable for science teaching in schools, development of integrated science curriculum for general and special learners of significantly higher and lower abilities (general mental ability), etc. seems to be needed for this purpose, so that inculcation of scientific vision and outlook, reasoning and thinking abilities etc. could be developed among the students of science beyond secondary level of education.

Therefore, it could be mentioned to conclude that all our educational endeavours should be made to inculcate a scientific imagination and outlook among the students at higher secondary level, the basic ingredients in the way to develop proper and positive attitude towards science, so that they must not depend solely upon the rugged traditions, mysticism, supernaturalism and superstitions, but on independent and logical thinking, rational analysis and logical reasoning.

Development of scientific thinking ability among each and every future citizen of India is the fundamental duty of all persons who are actively engaged in the field of science education from the very level of primary standards to the higher level institutions, formal or informal.

Science, not only cultivates scientific abilities and rationales but at the same time instills scientific temper and humanism, spirit of enquiry, motivation for scientific thinking ability development as well as acting, feeling and be-

having in a rational way etc., which are needed to achieve the above target. Therefore, to develop scientific attitude in a proper and desired way among learners and students of science to enhance their achievement significantly,

creation of interest and using interesting techniques of science teaching and learning are inevitable if we desire to face the ever increasing and changing problems and challenges ahead during the forthcoming twenty first century.

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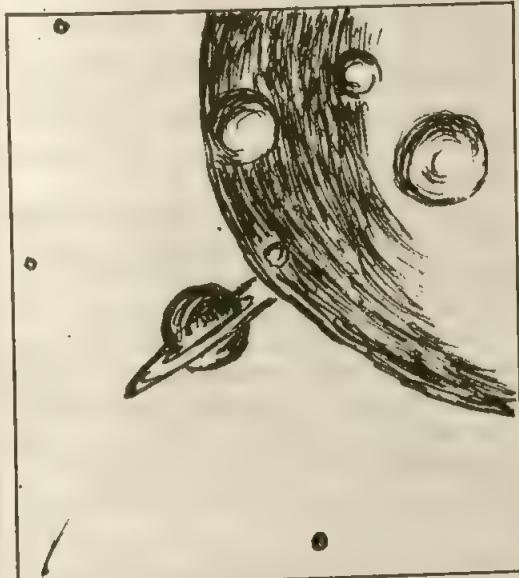
# Pathfinder — A Historic Mission in Space Exploration — A Report

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**A** new landmark in the history of space science was made on Friday, the 4th July, 1997 when the US Spacecraft — *Mars Pathfinder* — made a soft landing on the surface of the red planet Mars. For the

Americans it was a unique Independence day gift which falls on the fourth day of July. The spacecraft was launched in space in December 1996 and took nearly seven months to complete a journey of about 486 million kilometres. The *Pathfinder mission* is a part of an ongoing quest for the search of extraterrestrial life besides probing deeper into the atmospheric and geological conditions of the planet in order to refine present understanding about the origin of planets and the universe. This is for the first time in the last 21 years that a spacecraft from the Earth landed on the planet Mars.

The *Mars Pathfinder* project is one of the first Discovery class mission of the National Aeronautical Space Agency (NASA), USA. It is the first of the ten planned flights to the Mars over the next decade. Another spacecraft, *Mars Global Surveyor*, is already on its way to orbit the planet in September 1997. These are to be followed by another flights in the years 1998, 2001, 2003 and 2005.

The landing of the *Pathfinder* probe on the surface of the Mars has been a spectacular event. The probe comprised a single vehicle with a microrover (*Sojourner*) carrying with it several instruments to collect data on various aspects of the Martian surface and to transmit the collected information back to the Earth stations. At the time of its touch down on the Mars, the *Pathfinder* was cocooned in airbags with air-cushions all around it. As soon as it first touched the surface of the Mars, it bounced wildly for three times to almost 15 metres from the surface before coming to rest on boulder-strewn soil. The

*Pathfinder's* blossom like petals covered with solar cells were exposed to the Sun's rays as its covers got removed automatically on landing. Within ninety minutes radio signals from the *Pathfinder* confirmed its landing on the Mars. Soon afterwards, the *Pathfinder* began to transmit 3-D images, with remarkable resolution and clarity, back to the Earth.

When the *Pathfinder* began to transmit images of the surface features of the Mars, it became the first spacecraft to do so since 1970s when NASA sent two Viking probes to the planet. The main data collector of the *Pathfinder* mission is the microrover or the Sojourner which can move in all directions and over all types of terrain on the surface of the Mars. Its motion can be controlled through commands from the Earth station. Sojourner's mobility provides it the capability of "ground truthing" a land area over a few hundred square metres on the Mars. To investigate the surface of the Mars, the *Pathfinder* has been provided with three additional science instruments. These are, the Imager for the *Pathfinder* (IMP) which is a stereoscopic imager with spectral filters on an extendible mast, an Alpha Proton X-Ray Spectrometer (APXS), and an Atmospheric Structure Instrument/Meteorology package (ASI/MET). These instruments will enable the probe to carry out investigations on geology and surface morphology at sub-metre to a hundred metres scale, the geochemistry and petrology of soils and rocks, the magnetic and mechanical properties of the soil as well as the magnetic properties of the dust, a variety of atmospheric investigations and rotational and orbital dy-

namics of Mars.

The data in respect of surface morphology and geology at metre scale is to be provided by the Imager for the *Pathfinder* (IMP). It is envisaged that it will reveal Martian geological processes and surface-atmospheric interactions similar to what was observed at the Viking landing sites. Observations of the general landscape, surface slopes and the distribution of rocks are to be obtained by panoramic stereo images at various times of the day. Any changes in the scene over the lifetime of the mission might be attributed to the action of the frost, dust or sand deposition, erosion or other surface-atmospheric interactions. A basic understanding of the surface and near surface soil properties is expected to be obtained by the rover and lander imaging of rover wheel track, holes dug by the rover wheels and surface disruptions caused by airbag bounces or retractions.

The Alpha-Proton X-Ray Spectrometer (APXS) and the visible to near-infrared spectral filters on the IMP will enable the scientists to identify the dominant elements that make up the rocks and other surface materials on the landing site. A better understanding of these materials will address the questions concerning the composition of the martial crust, as well as secondary weathering products. These investigations will also provide a calibration point for the orbital remote sensing observations such as Mars Global Surveyor. The IMP is also designed to obtain full multispectral panoramas of the surface and underlying materials exposed by the rover and lander, since the APXS is mounted on the rover. Thus,

the data received from the Sojourner on this aspect is expected to characterize rocks and soils in the vicinity of the lander.

In order to study the magnetic properties and soil mechanics of the surface, magnetic targets have been distributed at various points around the spacecraft. Multispectral images of these targets are to be used to identify the magnetic minerals which make up airborne dust. In addition, APXS taking of the materials collected on the magnetic targets will enable the researchers to determine the presence of titanium and iron in the dust. It is expected that it would be possible to infer about the composition of the rocks by using a combination of images, and APXS measurements. Detailed examination of the wheel-track images will be utilized to get a better understanding of the mechanics of the soil surrounding the landing site.

The other important objective of the mission is to study the atmospheric structure as well as diurnal and seasonal meteorological variations of the planet. The Atmospheric Structure Instrument/Meteorology (ASI/MET) experiment has been designed to determine the temperature and the density of the atmosphere during the Entry, Descent and Landing (EDL). In order to measure atmospheric pressure during this period, the spacecraft has been provided with three-axis accelerometers. Soon after landing on the surface of the Mars, the Sojourner began sending meteorological measurements such as pressure, temperature, wind speed and atmospheric opacity. This data is to be collected on a daily basis. To facilitate this data collection, necessary devices

have been fixed on the Sojourner. For example, thermocouples mounted on a metre high mast will examine temperature profiles with height while the wind direction and wind speed will be measured by the wind sensor mounted on the top of the mast as well as by three wind socks interspersed at different heights on the mast. A proper understanding of this data is one of the essential requirements for identifying the forces which act on small particles carried by the wind on the surface of the planet. Regular sky and solar spectral observations using the IMP will monitor windborne particle size, particle shape, distribution with altitude and abundance of water vapour.

A study of rotational and orbital dynamics of Mars is another objective of the *Pathfinder* Mission. The *Pathfinder* Lander will utilize its Deep Space Network (DNS), by using two-way X-Band and Doppler tracking, to address a variety of questions related to the orbital and rotational dynamics of the planet. Ranging would involve sending of a ranging code to the lander on the Mars and measuring the time required for the lander to echo the code back to the Earth-based station. Dividing this time by the speed of light would enable the scientists to make an accurate measurement (within 1-5 metres) of the distance between the Earth station and the spacecraft. The basic principle involved is that as the lander moves relative to the earth station, the velocity between the spacecraft and the earth causes a shift in the frequency (doppler shift). Measurement of this frequency shift will provide an accurate measurement of the distance from the earth sta-

tion to the lander. It is envisaged that within a few months, such observations will provide enough data to determine the location of the *Pathfinder* lander within a few metres. Once the exact location of the lander is identified, calculations to determine the orientation and precession rate (regular motion of the pole with respect to the ecliptic) of the pole would be undertaken and the values so obtained will then be compared with those obtained by the Viking mission about 20 years ago. The measurement of the precession rate allows direct calculation for the moment of inertia, which in turn controlled by the density of the Martian rock with depth.

On learning about the landing of the Sojourner on the surface of the Mars, the initial reaction of the people, particularly of the scientific community, all over the world has been euphoric, if not hysterical. The red planet has perhaps been the only planet favoured by a host of the science fiction writers and television serial makers who stretched their imagination to create many a mysterious characters besides describing many of its features with such a vivid details that common man had a number of pre-conceived notions about its mysterious inhabitants and geographical features. The photographs transmitted by the *Pathfinder* blew off these myths beyond doubt.

For the scientists too, the *Pathfinder* has revealed many new evidences to corroborate or contradict existing knowledge about the surface features and rock formations of the planet. Water is present on the Mars has been debated for many years by the scientists but due to lack of convincing evidences

it has remained a mere speculation. The first few images received from the Sojourner has given signs of the existence of ancient water activity on the surface of the planet. Mission scientists while analyzing images, sent from 192 kilometres away, are of the opinion that a light coloured vertical mark on a hill side could be due to an avalanche gully. According to them the horizontal features on another hill could be terraces cut by moving water while horizontal rock layers laid down in a lake or a bathtub ringlike feature left along a shoreline are indicators of water activity. However, these initial interpretations of the images of the planet are tentative and may have to be modified after making further detailed analysis. Another significant discovery made from the analysis of the first few images from the Mars which again is tentative, is the suggestion that the life originated on the planet much before on the Earth. Some of the scientists have gone to the extent of suggesting that the life on the Earth has been transported from the Mars through meteors. However, it may still take a few more years to confirm these initial findings beyond doubt.

Unfortunately the Sojourner met with an accident within a week of its landing on the Mars when it got stuck while negotiating over a big boulder. Although scientists at NASA are confident of overcoming this hurdle, it may adversely affect some of the experiments planned through the project. Nevertheless landing of the *Pathfinder* on the Mars has been one of the giant steps in the annals of space science. It will definitely open up new horizons in the field of astronomy and space science.

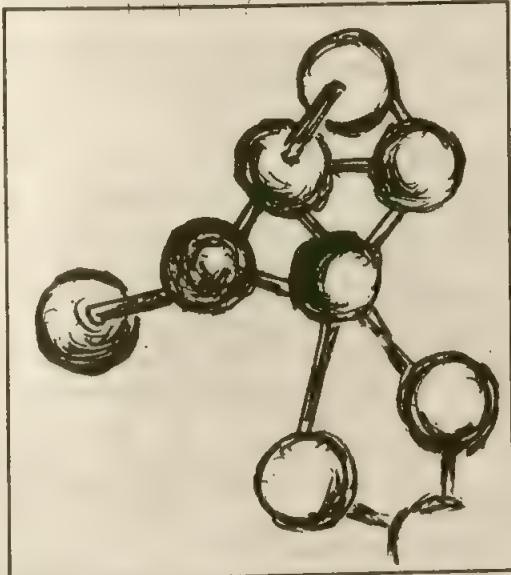
# Normality and Molarity in Acid-base and Redox Reactions

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**T**

oday, we try to solve most of our chemical problems on the basis of the *mole* and *molar quantities*. This is in fact more in practice after the *mole concept* was considered to be of fundamental importance.

Coming to volumetric analysis in our day-to-day laboratory work, we have started doing work taking 'molarity' as a basis rather than 'normality' in practice so far. Does it mean that we have got rid of 'chemical equivalent' or 'equivalence'? Answer is obviously, 'no'. Basic objective of putting 'equivalent' is that *one equivalent mass of a given reactant will react with exactly one equivalent mass of another*. But this 'equivalent mass' is not a fundamental quantity. The idea of 'equivalent mass' can be obtained from molecular mass. Former (equivalent mass) may vary depending upon the reactions whereas molecular mass (molar mass) always remains the same. This is the reason that these days even in volumetric analysis, we have started using molarity instead of normality.

## Defining Equivalence and Equivalent Mass

Generally, there are *two types of reactions* for which equivalent masses are defined (i) *neutralization reactions* in case of acids and bases and (ii) *redox reactions*.

The mass of one equivalent of a compound is called its equivalent mass. In general,

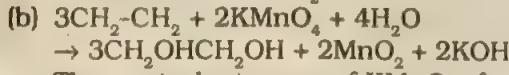
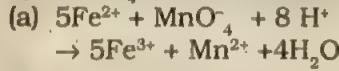
$$\text{Equivalent mass (Eq)} = \frac{\text{molar mass (m)}}{a} \quad \dots(1)$$

where the value of 'a' depends upon the type of reaction considered. How to calculate the value of 'a' is illustrated in the following examples.

(i) *For neutralization reactions:* Equivalent masses are based on the fact that one  $\text{H}^+$  (aq) ion reacts with one  $\text{OH}^-$  (aq) ion. One equivalent mass of an acid is the

amount of the acid that supplies one mole of  $H^+$  (aq) ions, and one equivalent mass of a base is the amount of the base that supplies one mole of  $OH^-$  (aq) ions. The value of 'a' in equation (1), therefore is the number of moles of  $H^+$  (aq) ions supplied by one mole of the acid or the number of moles of  $OH^-$  (aq) ions supplied by one mole of the base in the reaction under consideration. For example, 1 mol of  $H_2SO_4$  furnishes 2 mol of  $H^+$  (aq) ions, therefore 'a' will be 2 for  $H_2SO_4$ .

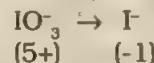
(ii) For oxidation-reduction (redox) reactions: Here, equivalent masses are based on change in oxidation number. In a redox reaction, the increase in oxidation number of one element must equal the decrease in oxidation number of another. An equivalent is defined in terms of change in oxidation number of one unit (unit here means per atom or molecule or ion in redox system). 'a' in equation (1) is the total change in oxidation number (either up or down) that the atoms in a formula unit of the compound undergo in the reaction under consideration. Now let us consider two reactions of  $KMnO_4$ . (a) oxidation of ferrous sulphate by  $KMnO_4$  in acidic medium, and (b) oxidation of ethylene by  $KMnO_4$ . Reactions can be written as:



The equivalent mass of  $KMnO_4$  for a reaction in which the  $MnO_4^-$  ion is reduced to  $Mn^{2+}$  ion (where change in oxidation number of Mn is 5), is the formula mass of  $KMnO_4$  divided by 5. The equivalent mass of  $KMnO_4$  for reaction (b) in which the  $MnO_4^-$  ion is reduced to  $MnO_2$  (where a change in oxidation

number of Mn is 3), is equal to formula mass of  $KMnO_4$  divided by 3.

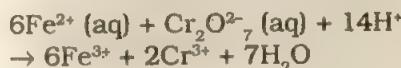
This aspect can be further highlighted by defining *equivalent mass* in more specific manner. An equivalent mass of an oxidizing or reducing agent in a redox reaction is the mass of that substance that gains or loses 1 mol of electrons. This definition ensures that one equivalent mass of an oxidizing agent reacts with exactly one equivalent mass of a reducing agent. As stated earlier, the value of 'a' for an oxidizing agent or for a reducing agent is just the total number of electrons gained or lost by one formula unit of the substance. Now, let us take a specific example of calcium iodate,  $Ca(IO_3)_2$  in which  $IO_3^-$  ion is converted into iodide ion,  $I^-$  after reduction,



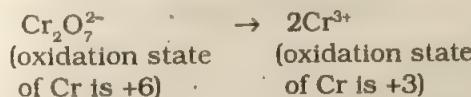
The oxidation number of iodine in  $Ca(IO_3)_2$  or in  $IO_3^-$  ion is +5 and in  $I^-$  it is -1. Change in oxidation state per iodine atom is 6. Therefore total change in oxidation state per formula unit of  $Ca(IO_3)_2$  is 12 as there are two iodine atoms. It can also be expressed in terms of electrons. In reduction of  $IO_3^-$  ion into  $I^-$  ion, each iodine changes by  $6e^-$ . Since in formula unit of  $Ca(IO_3)_2$  there are two iodine atoms therefore total number of electrons involved will be 12. Thus, in this reaction, 'a' is equal to 12. Therefore, 1 molar mass of  $Ca(IO_3)_2$  is equal to 12 equivalent mass of  $Ca(IO_3)_2$ . Therefore, the equivalent mass of  $Ca(IO_3)_2$  is  $1/12$  of the mass of a mole of calcium iodate or Equivalent mass

$$\text{of } Ca(IO_3)_2 = \frac{\text{mass of 1 mol of } Ca(IO_3)_2}{12}$$

This can be further illustrated by taking another example of reaction between iron (II) sulphate and potassium dichromate in acidic medium. The balanced ionic equation of the reaction is written as



Now for calculating equivalent mass of  $\text{K}_2\text{Cr}_2\text{O}_7$ , one has to examine the conversion of  $\text{Cr}_2\text{O}_7^{2-}$  into  $\text{Cr}^{3+}$  ion i.e.



Here oxidation state of Cr changes from +6 to +3 i.e a change of 3. But since there are two chromium atoms in chromate ion, total change in oxidation state per formula unit of potassium dichromate is 6. Therefore value of 'a' for the above reaction will be 6.

Therefore, equivalent mass of  $\text{K}_2\text{Cr}_2\text{O}_7$   
molar mass of potassium dichromate  
=  $\frac{294}{6}$   
=  $\frac{294\text{g/mol}}{6\text{Eq/mol}}$  = 49 g/equivalent

### Molarity and Normality and Their Relationship

The molarity, M of a solution is expressed as the number of moles of a solute per litre of a solution. Suppose n mole of solute is present in V litre of a solution, then

$$M = \frac{n \text{ mol}}{V \text{ litre}} = \frac{n}{V} \text{ mol per litre} = \frac{n}{V} \text{ mol L}^{-1}$$

Similarly, normality, N, of a solution is expressed as number of equivalents

of a solute present in one litre of a solution.

$$N = \frac{\text{number of equivalent}}{\text{volume in litre}}$$

Suppose w gram of a solute is present in V litre of a solution, m is molar mass and 'Eq' is equivalent mass, then

$$\text{Molarity, } M = \frac{w \text{ gram}/(\text{molar mass, } m)}{V \text{ litre}}$$

and normality,

$$N = \frac{w \text{ gram}/(\text{equivalent mass, Eq})}{V \text{ litre}}$$

Further,

$$\frac{N}{M} = \frac{w/\text{Eq}}{V} / \frac{w/m}{V} = \frac{m \text{ (molar mass)}}{\text{equivalent mass}}$$

= a (using equation 1)

Therefore,  $N = a M$  ... (5)  
or Normality = a × Molarity

Suppose we consider a substance A. The number of equivalents of A, in sample of solution of A,  $e_A$ , can be obtained by multiplying the volume of the sample,  $V_A$  (in litres) by the normality of the solution, N (which is the number of equivalents of A in one litre of solution)

$$e_A = V_A N_A \text{ (here } V_A \text{ is in litres)}$$

Similarly, if another substance B is considered, then,

$$e_B = V_B N_B$$

$$\text{By design, } e_A = e_B$$

$$\text{and therefore, } V_A N_A = V_B N_B \quad \dots (6)$$

Since a volume term appears on both sides of equation (6), therefore, any volume unit can be used to express  $V_A$  and  $V_B$ . For example, if we take  $V_A$  in mL (millilitre) then  $V_B$  also should be

in millilitre or if we take  $V_A$  in litre (L) then  $V_B$  also should be in litre.

Taking help of equation (5), equation (6) can also be written as

$$a_A M_A V_A = a_B M_B V_B$$

or in a more simplified way, we can write,

$$a_1 M_1 V_1 = a_2 M_2 V_2 \quad \dots(7)$$

For further illustrating this, we can select a numerical problem:

What is the molarity of a solution of  $H_2SO_4$  if 50.00 mL of solution requires 37.52 mL of 0.1492M N  $NaOH$  for complete neutralization.

Now if we apply equation (7)

$$a_1 M_1 V_1 = a_2 M_2 V_2$$

We find  $a_1$  for  $NaOH$  will be 1 as 1 mol of  $NaOH$  is 1 equivalent, and  $a_2$  for  $H_2SO_4$  will be 2 as 1 mol of  $H_2SO_4$  is 2 equivalents.

$$\therefore \text{Thus } a_1 = M_1 = \frac{V_1}{37.52\text{mL}}$$

$$1 = 0.1492M \quad ? = \frac{V_2}{50.00\text{mL}}$$

Therefore,

$$a_1 M_1 V_1 = a_2 M_2 V_2$$

$$\text{or } 1 \times 0.1492M \times 37.52\text{mL}$$

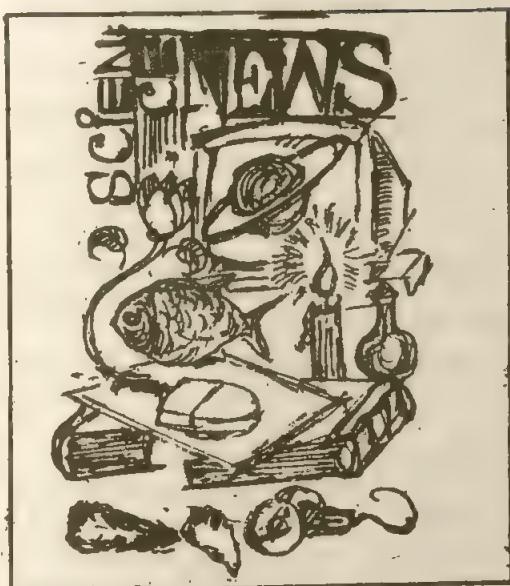
$$= 2 \times M_2 \times 50.00\text{mL}$$

$$M_2 = \frac{1 \times 0.1492M \times 37.52\text{mL}}{2 \times 50.00\text{mL}}$$

$$= 0.05596M = 0.056 M$$

Thus, taking molarity of the solutions for all our volumetric analysis is more convenient than taking normality. By doing this, students appreciate the basis of normality which is different for different reactions for the same substance.

## Science News



### Indian Scientists Develop Nuclear Detector

Indian scientists have achieved a major scientific breakthrough in the field of nuclear physics. A team of scientists at the Variable Energy Cyclotron Centre (VECC), Department of Atomic Energy (DAE), Calcutta have successfully developed a "nuclear detector". Many universities and national institutes have collaborated with the VECC in accomplishing this feat through painstaking research and development spread over a number of years. According to the leader of the research team Dr. Vikash Sinha, director of VECC and Saha Institute of Nuclear Physics, the nuclear detector is now at the European

### Accelerator Laboratory in Geneva.

The detector, first of its kind at the Geneva laboratory, is capable of detecting light particles that result from the collision between two atomic nuclei at velocities almost close to the velocity of light. The success has been acclaimed to be ingenious and original by many scientists active in this field. Dr. P.K. Iyengar, former Chairman of the Atomic Energy Commission described it as an excellent example of what Indian scientists can achieve. The project has been adjudged as ingenious, original and at par with the rest of the world by France based physicist Hans Gutbrod.

### INSAT-2D Satellite Launched

India's fourth commercial and second generation telecom satellite, INSAT-2D, was successfully launched from Kourou in French Guyana on Wednesday, 4 June 1996. According to the scientists at the Indian Space Research Organization (ISRO), the satellite was placed in a near earth orbit soon after its launch in which it takes about ten and half hours to go once around the earth. After a number of successful manoeuvres, the satellite was finally placed in its predetermined parking slot close to its predecessor INSAT-2C after about thirty days of its launch.

A number of tests are to be carried out to ensure proper functioning of various components and systems of the satellite before it is put to commercial use. Once the satellite INSAT-2D becomes fully operational it is envisaged that it will usher the country in an era of communication revolution. The sat-

ellite has been designed to provide an additional 21 high power transponders and two exclusive facilities to the Indian space segment.

The ISRO is now set to consolidate its experiences and expertise to further boost nation's image as an emerging space super power. It had planned to launch indigenously its first operational remote sensing satellite from Indian soil by the end of 1997. The Polar Satellite Launch Vehicle (PSLV), developed and successfully tested by the ISRO earlier, is scheduled to blast off from the Sriharikota carrying it the remote sensing satellite IRS-1D. India has already established its name in the field of remote sensing. The data gathered by its existing remote satellite IRS-1C is being utilized by a number countries including developed ones.

The ISRO had also made significant advancement in the development of cryogenic engines to be used in its Geosynchronous Satellite Launch Vehicle (GSLV). According to Dr. K. Kasturirangan, Chairman, ISRO and the Secretary, Department of Space (DoS), the department had an outstanding track record in building 1000 kg remote sensing and 2500 kg multipurpose INSAT class satellites as also rockets that can put IRS class satellites in an earth orbit. In the next phase of consolidation of its space programme, ISRO's plans include launching of two more advanced INSAT satellites for remote sensing and communication and to build up commensurate launch capability besides development of the first of the third-generation INSAT-3 spacecraft, and two more remote with sensing satellites. All these satellites, except

INSAT-2E, are expected to be launched from India. Once this is accomplished India will no longer be dependent on foreign countries for launch operational facilities for its space crafts. INSAT-2E, the last in the series of second generation Indian spacecraft built by ISRO, will be launched from Kourou in 1997-98.

The first of the future remote sensing satellites, IRS-P4-Oceansat is expected to be launched in 1998-99 followed by IRS-P5-Cartosat in 1999-2000. The plans for the development of the next generation INSAT-3 series had been finalized by the ISRO. At the same time work has also began on the G-SAT series of satellites to be launched by developmental flights of Geosynchronous Satellite Launch Vehicle (GSLV). The satellites launched through GSLV flights are to be utilized for digital audio-visual broadcasting. This broadcasting system is envisaged to aid long distance education, low cost messaging, tele-medicine and wide band services. Boosting of personal mobile satellite communication and navigation systems are also on the agenda of the ISRO's future satellite projects.

### **Scanners to Identify People by Hands, Eyes or Voice Developed**

In modern societies an individual is often asked to establish his or her identity e.g. in banks, at the time of migration or voting. Signatures, attested photographs, finger prints are some of the modes which are commonly used for this purpose. In the recent past the number of situations in which a person

is expected to establish his or her identity has gone up many fold. The search for a foolproof, quick and reliable method of identification has been going for some time. Scientists have now come out with a technique which fulfills this requirement. These devices are based on the fact that certain features of every individual are unique to him or her. For instance, the structure of the iris, the patterns on the palm or the finger or certain characters of the voice of a person does not change with age. These "biometry identity" devices maintain a record of the characteristics of individuals in a computer and compare them at the time a person presents himself for identification.

The new class of futuristic gadgets will just scan a person's eyes, hands or voice and instantly verify the identity of the person. The future automatic teller machines (ATM) in banks are likely to pan a camera across one's eyeball to verify his identity. Similarly, for maintaining the record of the arrival and departure time of workers in an organization, just pressing one's palm on the surface of the device will be sufficient. A voter in future may just have to speak a few words before a microphone to establish his or her identity.

### World's Fattest Rats Created

Scientists at the National Institute of Nutrition (NIN), Hyderabad has been successful in developing a colony of rats which perhaps are fattest in the world. Each of these rats weighs on an average 1.4 kg as against the normal 300 gram. Biomedical researchers intend to utilise this new strain of over-

weight rats as 'models' to develop cures for obesity and diabetes, the two major problems afflicting people all over the world.

According to Dr. N.V. Giridharan of the NIN's laboratory animals information centre what they have obtained is a pure strain of obese rats having immense potential in facilitating biomedical research. The strain of fat rats have been created through selective breeding spread over a couple of years. Breeding the fat rats has not been an easy task for Giridharan and his colleague. These were developed from the natural mutants that had evolved through inbreeding of the "wistar" rats maintained by the NIN for the last 75 years. The first step involved was to spot and isolate the mutants and then selectively breed them in large numbers. The present lot of about 400 fat rats maintained at the NIN are in the 11th generation. Breeding fat rats had not been an easy task as the males turned out to be infertile and the females had delayed puberty. Only rats which were "carriers" of the genetic mutation had to be mated to establish the colony. Identifying the carriers had been comparatively easy as the rats carrying obesity genes had "kinky" tails. These fat rats has been named *Wn-in-ob*.

According to Giridharan, among the fat rats, there is a group of animals which has "impaired glucose tolerance". These will be excellent experimental models to develop drugs for treating diabetes associated with obesity. The next step in this line of research would be to analyse the genetic material of the fat rat to identify and localise the specific genes for obesity and impaired glu-

cose tolerance. Scientists believe that identifying and cloning of the specific genes could lead to the development of cure for obesity but it would involve lot of money and time. Scientists at the National Institute of Health of the United States of America have shown interest in collaborating with the NIN in this phase of research.

In addition to facilitating research, the fat rats developed by the NIN may also prove to be source of revenue generation for the institute. The fat rats of the NIN are claimed to be genetically purer than the *Zucher* and *Koletsky* rats available for the purpose of medical research. This because these two varieties were developed from "out bred" stocks and therefore are genetically less purer than NIN's strain developed totally from the inbred colony. At present, each *Zucher* rat is sold for a few hundred dollars and the companies which sell them make sure that they are not used for breeding. NIN's fat rats may break this monopoly.

### **Gamma Knife Facility Installed at AIIMS**

All India Institute of Medical Sciences (AIIMS), New Delhi has acquired a sophisticated Leksell Gamma Knife facility. The facility will be utilised for the treatment of vascular malformations and small tumours of the brain without surgical intervention. At present only two centres have this facility in the south Asian sub-continent, the other being PD Hinduja National Hospital in Mumbai.

The gamma knife was developed nearly thirty years ago by the Swed-

ish neurosurgeon Lars Leksell. Since then many improvements and modifications have been carried out in order to further refine it. It has been accepted by the medical world as technical aid for about a decade or so.

A gamma knife is a device which focusses 201 weak beams, from different directions, precisely to achieve a high level of radiation at the desired point. This destroys the vascular malfunctions or the tumour, thereby ablating it or arresting its growth. The procedure involves fixing a stereotactic frame onto the head of the patient and conducting a diagnosis — CT scan or an angiogram. The target tumour is identified and localised by reading the coordinates. Highly advanced computers are used for devising the treatment plan by calculating the radiation dose and direction. The whole procedure takes a few hours and radiation time just about 20 to 30 minutes. Compared to the conventional, invasive, neurosurgery, the treatment with a gamma knife involves a shorter hospital stay and negligible morbidity and mortality.

The name gamma knife is somewhat misleading because it is not a knife in conventional sense. It provides an intense and sharply focussed beam of gamma radiations which can destroy (remove) a vascular malformation or a tumour just like a knife. The biggest advantage it provides is the precision and accuracy which are very important in neurosurgery. The gamma knife has fulfilled a long cherished desire of neurosurgeons to acquire a tool that may provide the precision and accuracy required in neurosurgery.

## Comet and Asteroid Specialist Shoemaker is Dead

Eugene Shoemaker, co-discoverer of the Shoemaker-Levy 9 comet that crashed into Jupiter in 1994 died on July 18, 1997 in a car accident in central Australia. He was 69. His wife and long time scientific collaborator, Carolyn was also injured in the accident.

Shoemaker did pioneering work on the Barringer Meteor Crater near Winslow in Arizona and proved that it was the result of a strike by a meteor that exploded upon impact. He was one of the earliest to propose the idea that asteroid or comet impacts may have caused mass extinction — including the one that wiped out the dinosaurs. He is considered to be the creator of the concept that Earth and the planets are pummeled by asteroids and comets.

In 1973, Shoemaker and his wife Carolyn began a survey of asteroids that cross Earth's orbit in order to try to discover the threat they pose to the Earth now. In the process they discovered more than 800 asteroids. Their best known discovery, however, was the fragmented comet that plunged into Jupiter which the scientists could watch in nearly real time. With the untimely death of Shoemaker, the world has lost one of its pioneering specialist on comets and asteroids.

## Antibiotics Cut Heart Attack Risk

A team of cardiologists have found that killing off a pneumonia causing bacterium in an infected cardiac patient reduces the risk of a second heart at-

tack. The results of a pilot trial carried by the team comprising Dr. Sandeep Gupta and colleagues at St. George Hospital Medical School, London has been published in the journal *Circulation*. Their findings suggest that antibiotics could become a cheap treatment for some types of heart disease.

The present study has been a sequel to the detection, by researchers last year, of a bacterium called *Chlamydia pneumoniae* in the arterial blockages of 75% of the patients with atherosclerosis or partially clogged arteries. Dr. Gupta and his colleagues reasoned that if the organism were somehow causing blood clot, then killing *Chlamydia pneumoniae* by antibiotics might cut a patient's heart attack risk.

Pursuing their line of argument, Dr. Gupta and his team measured the blood levels of antibodies to *Chlamydia pneumoniae* in 213 male patients who had previously suffered a heart attack. Eighty of these patients had high antibody levels, presumably indicating a more serious chlamydia infection. The researchers treated half of these patients for three days with azithromycin, an antibiotic that wipes out chlamydia infection. Eighteen months later, only 8% of the treated men had suffered another heart attack or other serious cardiac event or had died: in contrast, 28% of those who were untreated or given placebos suffered another such consequence. Among the 59 men who initially had no chlamydia antibodies, the rate was 7%.

These results have been described as provocative by other researchers working in this field. However, they have suggested that a larger study

should be undertaken to prove the benefit of treatment and to determine whether it also helps patients who have not already suffered a heart attack.

If azithromycin proves to be a treatment for heart disease, it could be particularly beneficial in developing countries like India where the rate of heart disease is rising very fast and the present mode of treatment involving bypass surgery and balloon angioplasty are beyond the reach of a large number of patients being very expensive. Dr. Gupta, however, cautions that the antibiotics might not be effective in all types of heart attacks and therefore the best strategy for preventing heart diseases will still be to avoid the big risk factors — smoking, lack of exercise and improper diet.

## Predators Maintain the Balance

The reason behind the same kind of animals appearing in different colours in nature is usually the environment. But it has been found that the red and green aphids live side by side in the same alfalfa fields. Why doesn't natural selection weed them out one kind of hues? John Losey, an entomologist at the University of Wisconsin, Madison, USA and his colleague have found an answer to this question. According to a report published in 'Nature', Losey claims that it is because the two aphids' major predators have different liking for different colours.

In order to find out why both red and green aphids survive, the team of researchers led by Losey looked at how the two enemies of pea aphids — la-

dybug and wasps — affect the population. They sampled 100 alfalfa stems in eight similar locations every day for one whole summer. They counted the number of red and green aphids, ladybugs and mummified remains of aphids parasitized by wasp larvae. They discovered that the predators had distinct preferences — ladybugs being partial to red aphids and wasps to the green aphids.

The result is that the two predators keep the colour balanced. With ladybugs eating the red aphids and wasp larvae parasitizing the green, neither form dominates the population and survive. The finding supports the idea of conserving whole ecosystem — including predators — rather than just single species.

## Alzheimer's Mutations Linked to Cell-death Process

A group of researchers led by Rudolph Tanzi, director Genetics and Aging Unit at the Massachusetts General (MGH), USA have discovered that two genes associated with early onset Alzheimer's disease are involved in programmed cell death a natural process in which unneeded or worn out cells commit suicide. Their study have also shown that an Alzheimer's-causing mutation in one of these genes increases the propensity of nerve cells to undergo the cell-death process, which is also called apoptosis.

Reporting about their work in the journal 'Science', the researchers have described their studies of the protein products of two genes called presenilins. According to Dr. Tanzi the study directly and clearly connects

these Alzheimer's genes with apoptosis, which has long been suspected as a mechanism in several neuro-degenerative diseases.

As a result of this study, both the types of presenilins now join a select group of proteins which help bring about cell death. In the brain, this process usually takes place during early growth, when extra neurons (brain cells) die to assure proper development. It has been hypothesized that in older individuals the cell-death pathways becomes reactivated in certain neurons, especially in the regions affected by Alzheimer's. While mutations in these genes appear to speed up this process and cause early-onset Alzheimer's, environmental factors could set off the process in sporadic cases of the disease. Thus, the discovery creates an excellent target for new drug development.

Presenilin (PS) 1 (which is located in chromosome 14) and PS2 (which is located in chromosome 1) were both discovered in 1995. When mutated, PS1 (which is also called S182 and STM-1) is believed to cause roughly 50% of inheritance, early-onset Alzheimer's, while PS2 (also called STM-2) is associated with a much smaller proportion. Defects in both genes are directly causative: anyone who inherits a mutated form of the gene is destined to develop the disease, usually before the age of 65.

When apoptosis takes place, many of the proteins that make up a cell are clipped apart by certain enzymes called caspases. Although clipping proteins into smaller fragments is a normal part of cellular metabolism, apoptosis-associated clipping takes place at alterna-

tive locations along the protein strand, changing the molecular message carried by the protein and eventually leading to the cell's death. The new findings suggest that presenilin proteins are cell-death substrates — proteins that are clipped by the caspases to carry out the process of cell death.

To confirm the presenilin proteins' cell-death role, the MGH researchers analysed the proteins produced by cultured neurons under normal conditions and after apoptosis was induced by substances that trigger the process. They identified the sites at which both presenilins were clipped in normal cellular processing by isolating the two fragments the original proteins were cut into. When cells undergo apoptosis, the researchers found, both presenilins are clipped in alternative locations, producing different protein fragments that contribute to the cell-death process.

Tanzi believes that the development of the drug that interferes with the caspase-induced alternative clipping of presenilin proteins might delay or prevent the progression of Alzheimer's.

### **Alterations in the Chemical Pathways of Cells Made Possible**

It is well known that the bacteria develop resistance to conventional antibiotics after some time. The antibiotics, therefore, have to be continuously replaced or modified to be effective on the new resistance variety of bacteria. Scientists have been trying to evolve techniques which may enable them to develop new versions of the old wonder drugs. However, the complex molecular

architecture of many of these antibiotics had proved to be extremely difficult parameter to synthesize new versions. A group of biochemists in a report published recently in the journal *Science*, have described a way to hijack the antibiotic-producing chemical pathways of the bacteria, and exploit them to produce a wide variety of new compounds.

Bacteria manufacture their cellular products with an assembly line of some 30 enzymes. But in the natural world, that process is limited to molecular building block at hand in the cell. The present day chemists are capable of producing far richer array of building blocks than is possible in natural world. So Chaitan Khosla, a chemical engineer at Stanford University, and his colleague decided to give bacteria some new building blocks to work with.

The researchers started with *streptomyces coelicolor*, an organism that is easy to manipulate genetically. They had previously engineered the bacterium to express the entire series of enzymes needed to make the common antibiotic erythromycin. Using conventional genetic engineering tech-

niques they disabled the third enzyme in the series, preventing it from stitching together a single six-carbon chain. According to Khosla, this is the most crucial step in the entire process.

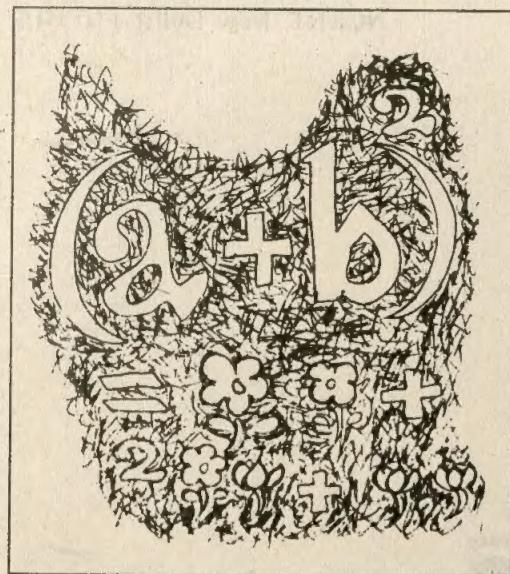
To restart the assembly line, the researchers substituted synthesized molecules slightly different from the six-carbon chain. These stand-ins were taken up by a subsequent enzyme and passed along until a final new compound emerged at the end of the assembly line. Khosla asserts that these enzymes seem to be very tolerant to using new substrates which is quite encouraging for making novel natural products. A final processing step at the end to add sugar group converted these products into active antibiotics.

Biochemists are quite optimistic that this research would open the door of making a bunch of new molecules quickly. However, they are not equally optimistic that the technique could be scaled up for industrial production because the building block for the analogs must be specifically synthesized, which can be both time consuming and expensive.

## **Book Review**

### **Fundamentals of Mathematics**

By P.N. Arora, published by Sultan Chand and Sons, New Delhi 110002 (10th Edition), pp 1050, Rs.140.



The book 'Fundamentals of Mathematics' is written by Dr. P.N. Arora. This huge, magnanimous book is published by Sultan Chand and Sons and costs Rs.140. The author has acknowledged contributions of not less than thirty-

two eminent teachers of Mathematics for their contributions towards the book, which shows the amount of efforts made by all of them to prepare a consolidated simple, and complete book for the student to understand the subject and to practice. The author rightly believes "**Mathematics without practice is blind, practice without theory is sterile**".

The book is divided into 11 chapters, each chapter is a small book in itself with number of pages ranging from 58 to 146.

A large number of questions are taken from DSSE and AISSE and many of them have been solved, too. Large number of questions on determinants have been solved. The question no. 24 on page 1.89 should have been written explicitly as  
Show that :  $A = \begin{bmatrix} 5 & 3 \\ -1 & -2 \end{bmatrix}$

satisfies the equation

$$A^2 - 3A - 7I = 0$$

and hence find  $A^{-1}$

Elementary row transformation has also been added. Graphs of different functions have been given in detail and explained very thoroughly.

Since convergency and divergency of the series is not in the syllabus of +2, it would be better if an alternative method of getting  $\frac{d}{dx} x^n$  be given on page 3.10.

Most of the chapters are very well written. In the chapter on 'Matrices and Determinants', the author has divided chapters by starting with definition of various types of matrices, their basic operations, etc. In 3 D both Cartesian and vector approach have been fol-

lowed. In Correlation and Regression, the author has given the relation between regression analysis and correlation analysis so that the students may understand the ideas of correlation and regression more clearly. Rank method of finding the correlation is also given which may be useful to the students of other states wherever it is in the syllabus. Some misprints are, however, here and there, but I hope these will be removed in the next edition.

In all an extensive work has been done in bringing out the book and efforts have been made to present 'one book' which can act as a text reference and practice book for the students. The

book is also meant for those who are motivated to study mathematics as a specialised discipline at an advanced level and intend to appear for Class XII examination of various Boards. It will help the students who plan to study Engineering and are preparing for various entrance examinations. The book deserves a place in Secondary and Senior Secondary School Library and personal book-shelves of students.

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